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AND

DR. W. A. HOLDEN
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VOL. XLVIII. No. 5.

ARCHIVES OF OPHTHALMOLOGY.

CONCERNING THE OCULAR PHENOMENA IN THE PSYCHONEUROSES OF WARFARE.[1]

BY G. E. DE SCHWEINITZ, M.D., OF PHILADELPHIA, Colonel, Medical Section, O. R. C., U. S. Army.

(With six illustrations on Text-Plates XI. and XII. and one figure in the text.)

THE opportunities for the observations on which this communication is based were afforded in France and England in the winter of 1917–18, and in this country in U. S. Army General Hospital No. 30, Plattsburg Barracks, in December, 1918.

It is not necessary to discuss in detail the confusion which has occurred by reason of the unfortunate application of the term "shell-shock." Because in the earlier years of the war many men who had been exposed to shell-fire, or had been in the near vicinity of exploding shells, developed in unusual degree a variety of nervous phenomena, these were attributed to the concussions resulting from the explosions, and the term "shell-shock" came into existence. Later all manner of nervous manifestations not specifically associated with what are ordinarily known as "peace-time neuroses" were classified under the same designation.

It is now well established by the studies of many expert observers that the majority of these cases are examples, to use an oft-recorded definition, of "peace-time neuroses with a

[1] Paper read before the American Ophthalmological Society, June, 1919.

war-time coloring,"[1] and the "neurosis is a maladjustment of the individual to his environment; his way of meeting a difficult situation." It must always be remembered, as Parsons points out, that the results of a true neurosis, be it one of war time or one of peace time, are not conscious or voluntary.

Such cases have been classified by various systematic writers. Pearce Bailey[2] makes the following divisions:

1. *Concussions*, the affected individual having acquired minute, disseminated lesions of the central nervous system. Some recover quickly; some do not recover, at least, not satisfactorily, and some pass over into a neurotic state—an implantation of a neurosis on an organic base. The percentage of those who develop symptoms indicative of true brain concussion is comparatively small.

2. *Neuroses of Neurasthenic or Psychasthenic Type.* These, as before noted, do not differ materially from the neuroses of civilian life. Some have symptoms suggesting endocrine disturbances. A certain number of cases develop as the result of intense physical exhaustion and recover quickly after rest.

3. *Hysterias.* These, if Babinski's conception of hysteria is accepted, represent conditions produced by suggestion and curable by psychotherapy.

Captain L. C. Frost[3] has proposed a more condensed classification, or grouping, to wit:

Group A. Shell concussion, to include such cases as present obvious physical lesions, or at least, such symptoms as may be assumed to interpret physical lesions. These comprise those individuals who have experienced concussions from exploding shells, the effects of atmospheric and gaseous compression, poisoning by carbon monoxid, etc.

Group B. Shell hysteria, psychoneurosis, and war shock, including those cases grouped in paragraphs 2 and 3 of the previously quoted classification. They should include those who, suffering temporarily from physical effects, recover from them, but acquire nervousness, or, as Captain Frost puts it, the

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[1] F. W. Parsons, "War Neuroses," *Atlantic Monthly*, March, 1919.

[2] "War Neurosis, Shell-Shock, and Nervousness in Soldiers," *Journal A. M. A.*, vol. lxxi., p. 2148, 1918.

[3] *The Military Surgeon*, April, 1919, p. 350.

transitory physical symptoms furnish not the cause but the starting point of the nervous phenomena—the affected individual becomes abnormally centered in the somatic symptoms.

Disregarding the comparatively small group of "concussioned" cases with organic lesions, except in incidental mention, I shall attempt to describe some of the ocular phenomena which pertain to those who comprise the functional group, *i. e.*, those with psychoneurosis, war shock, and hysteria. It is admittedly difficult to make sharp distinctions; they readily become artificial. So also a definite classification of the ocular symptoms is not a satisfactory one. However, for convenience' sake, the conditions may be grouped as: (1) Various types of amblyopia and amaurosis, including disturbances of color vision, types which in civilian practice have been included under the terms "incomplete and complete anæsthesia of the visual sense." (2) Asthenopias and anomalies of accommodation. (3) Anomalies of the iris movements (pupil phenomena). (4) Anomalies of the eyelid and exterior eye-muscle movements. (5) Phenomena not included in the preceding groups.

1. *Amblyopia, Amaurosis, Achromatopsia, and Dyschromatopsia.* To this group belong reduction of visual acuteness, or its complete loss, disturbance of the color sense, and anomalies of the visual field.

(*a*) *Amblyopia and Amaurosis.* Ordinary reduction of visual power in hysteric patients is of no special importance, but the knowledge of a refractive error as it may have been reported, for example, by the examining officer at the time of the man's induction into the service, may readily furnish the suggestion which determines the symptoms of reduced acuteness of sight, for example, below the standard required in the army. Also the symptoms may be removed through the same channel.

> Thus, a simple-minded recruit from the mountain regions of the southwest had been told by some traveling "eye doctor" during the period of his few months of "schooling" that his eyes were "weak" and "needed glasses." Bewildered by the strange surroundings of a training camp, backward in the acquisition of his duties, unmercifully "ragged" by his comrades, knowing that replacements for overseas work were being rapidly formed, dreading his in-

feriority because of supposed "weak eyes," alarmed by cruel stories of the horrors of foreign warfare, he developed a typical neurosis, the prominent symptoms being tremor, whispering voice, and amblyopia, the visual acuteness being reduced to less than $\frac{1}{10}$ of normal. At first all attempts to improve the vision, although the eyes were perfectly healthy, were fruitless. The suggestion gently but insistently made that spectacles would restore the lost quota of sight and put him on an equality with those who possessed normal vision, with whom he would surely have to go, stimulated the instinct of self-preservation and vision became absolutely normal through glasses of negative refractive power. In the first instance he released himself from an intolerable situation by the development of a defect suggested by the eyes and in the second place relieved himself from an anticipated situation more intolerable than the first one by putting himself on equality with his comrades in the game of self-preservation, the restoration of vision suggesting the method of release.

Sometimes in place of a reduction of sight as tested with type-cards, the patient persists that the vision is "smoky," or "foggy"—"nothing has ever been clear since I was shell-shocked." This may be a temporary condition, but in some soldiers remained for a long time, that is, long after all other signs of "nervousness" had apparently passed away.

It is possible that in some instances there really is an ocular cause for the blurred or cloudy vision. Thus, Terrien[1] describes clouding of vision, which gradually ameliorates until there persist a diminution of visual acuteness and marked difficulty in fixing objects. He noted under these conditions retinal and papillary hypæremia, and suggests the possibility of retinal commotion as the cause of the foggy sight.

Referring now to complete, or practically complete, blindness among war neurotics, Kron's classification of bilateral hysterical amaurosis, as noted in civilian practice, made years ago,[2] may with propriety be retained with a few slight modifications: (*a*) Transitory forms lasting a few minutes; Auer has described transitory blindness lasting fifteen to twenty minutes,

[1] *Paris Méd.*, vol. v., Nos. 20, 31, September 25, 1915, pp. 338–349.
[2] *Neurologisches Centralblatt*, xxi., 1902, p. 584.

after a reprimand, fright under fire, or exposure to cold[1]; (*b*) short-enduring forms lasting for several hours to two weeks[2]; (*c*) long-enduring forms, lasting for months or even years.[3]

In general terms, the evolution of hysteric blindness, which may be more or less complete after a soldier is "shell-shocked" is as follows: During the period of being semiconscious, or dazed, he is partly or entirely blind; vision often returns with the restoration of consciousness, or it may persist for varying periods of time, as already described, if the soldier's attention is fixed upon, or directed to, his eyes. Thus, as previously pointed out, and as noted by A. F. Hurst,[4] an error of refraction by a process of auto-suggestion may perpetuate the loss of vision.

Associated with this psychic or hysteric cecity, there may be tonic blepharospasm, that is, a convulsive closure of the lids, or clonic blepharospasm, that is, continued blinking of the lids, sometimes designated "fluttering" or "twinkling" of the lids. If an effort is made to raise the lid a definite resistance is demonstrable; if the patient under command tries to open the eye, the only response is a trembling movement with no or only slight separation of the ciliary margins. On forcing open the lids the eyes are usually rotated upward and cannot be turned downward. The pupils react normally. The eye-grounds show no changes.

The symptoms of these neurotics, and therefore also the amblyopias, do not, to use Frost's words, "arise haphazard, and they are always the definite effect of a definite suggestion in some form." He quotes Colonel Salmon in this regard: "The symptoms exhibited usually bear a more direct relation to the existing psychological situation than they could possibly bear to the localization of a neurological injury. Thus, a

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[1] *Med. Record*, New York, lxxx., 1916, 641–644.

[2] Coutela has recorded loss of vision lasting four hours to two days, *Archives d'ophtalmologie*, vol. xxxv., No. 9, May–June, 1917, 539–556. This paper discusses visual disabilities the result of cranial commotion, and in those examples which arise in the absence of lesions he ascribes the major influence to "Hysterie Pithiatisme."

[3] Coutela, *loc. cit.*; F. Moreau, *Annales d'oculistique*, clvi., March, 1919, p. 156.

[4] *Medical Diseases of the War.*

soldier who bayonets an enemy in the face may develop an hysterical tic of his own facial muscles; hysterical blindness may follow particularly horrible sights, etc." A case recorded by F. W. Mott[1] illustrates this point. A shell burst near a man while he was attending to a wounded comrade. He dragged the wounded man into a culvert, but then found he was unable to see and had to be helped out. The emotional shock and the darkness of the culvert were responsible for the loss of visual function.

The restoration of vision may be prompt or deliberate, as already stated. According to J. Herbert Parsons, the eye to recover last is often the "shooting eye." In some cases there is a prolonged period of dull or smoky vision, or when the acute blindness subsides defective vision may remain, dependent upon spasm of the ciliary muscle, the apparent myopia thus produced being correctible with concave glasses.

Hysterical amblyopia or amaurosis of the character now under consideration may be bilateral or unilateral. Eder[2] states that unilateral amblyopia is probably more common than double amblyopia. This has not been my own experience. In those cases personally investigated in all instances both eyes were affected, but not always to the same degree. It has been stated by Cruchet[3] that the first color seen by the patient on recovery from hysteric blindness is red. His observations were made in civilian practice. Whether a similar observation has been made among those suffering from war neuroses I do not know; personally I have no records in this regard.

Hurst maintains that the affected soldier does not move about like a blind man, but avoids hurting himself, though he does not relax the groping action of people with extremely defective sight. This observation was frequently made and commented upon by the earlier students of the visual phenomena of hysteria. In a word, the orientation of the affected individual is usually perfect. Various writers have in days gone by attempted a variety of explanations of this fact. Thus, it has

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[1] *Trans. Med. Soc.*, Lond., 1915–16, xxxix., pp. 157–226.

[2] *War Shock. The Psychoneuroses in War, Psychology, and Treatment*, London, 1917.

[3] *Archiv de neurologie*, 2 Series, xii., 1901.

been suggested that the peripheral visual impressions, although unperceived, bring about in the muscular apparatus, to use the language of Parinaud, those instinctive and unconscious movements by means of which we find our way through the external world. Groenouw states that hysteric patients with greatly contracted fields find no difficulty in getting about because the periphery of the retina still retains its power of perceiving large and bright objects. Wilbrand explains the phenomena by assuming that the irritability of the retinal periphery is not lost, and that the insufficiency of the retina is not so great when the patient is moving about as it is during steady fixation.

Such lack of inconvenience from contracted vision is, however, not always evident, as, for example, in the following case, quoted also as representative of the enduring forms of hysteric blindness.

> A colored soldier, aged 20, with a service of one year, part of which (from April, 1918, to November, 1918) was in France, while engaged in laying rails, began to complain of painful and inflamed eyes, which steadily grew worse as he was sent from one camp hospital to another, until finally he was returned to this country. There is no history of "shell-shock" in the ordinary sense of that term, but what may have been a slight conjunctivitis furnished the suggestion of an escape from an intolerable situation. The records state that his vision was respectively $\frac{6}{200}$ and $\frac{4}{200}$, but when I examined him in December, 1918, it was not nearly equivalent to that, being at best object perception, and that uncertainly. Except for a moderate clonic blepharospasm and the blindness, his eyes and eye movements were normal in all respects. The records state "he stumbled over objects placed before him." He exhibited an almost constant general tremor, was excessively nervous, "jumpy," to use a colloquial term. Called from the hall into the examining room, he came with the hesitating step of a blind person but failed to avoid objects in the room, and once walked into a small metal chair, which, striking the floor, made a crashing noise that sent him into a fit of trembling so violent that it simulated a general convulsive seizure. He was not a malingerer (he was closely watched for a long time), and suffered real mental distress. After one month of treatment by suggestion, aided with electricity, he made a complete recovery in all respects. The first visual field obtainable was extremely concentrically contracted, and day by day

widened until it assumed a fully normal extent. His period of blindness, therefore, lasted approximately eight months. (Figs. 1–4.)

It is necessary to be thorough in the examination of the cause of the blindness, or of the defective vision, in some of these cases, for occasionally, although the general symptoms of neurosis are present, and the history of shell or other type of war shock is complete, the eye phenomena in so far as they pertain to sight are really due to ocular lesions. I have referred to the possible relation of commotio retinæ to this condition.

Laignel-Levastine and Courbon[1] describe the case of a soldier previously syphilitic who had been "shocked" sixteen months prior to examination, which was followed by stereotyped "blinking" of the lids, and who was practically blind—a blindness not due to malingering and not susceptible to improvement under the influence of suggestion—who had also external strabismus of the left eye and limitation of the exterior ocular movement in attempted rotations to the right, upward and in convergence. The pupils were small, but normal in reaction, and the papillæ showed only a slight departure from normal appearance. These changes and paresis of the ocular movements were attributed to meningitis; the blindness was not considered as an hysteric manifestation, although other symptoms of hysteria were clearly in evidence. Babinski, discussing this case, referred to observations of his own after cranial trauma, but also after "shell shock," where a diminished visual acuteness was noted ($\frac{4}{10}$ – $\frac{2}{10}$ or lower), the papillæ being slightly hyperæmic and mellowed. The disturbance of visual function he considered to be out of proportion to the ophthalmoscopic findings (in some instances these were normal), and suggests that nerve-head changes are due to an organic disturbance of unknown origin.

As an example of the difficulty in deciding whether sudden loss of vision should be ascribed to hysteria, or rather to a psychoneurosis, or to an organic change, the following case may be recorded.

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[1] *Rev. Neurolog.*, i., 1916, vol. xxiv., p. 402.

While crossing on a transport, a boy, aged 19, of good repute and on duty in "the eyes of the ship," on a raw, windy, and cold day went suddenly practically completely blind, and was examined a few hours later in the sick bay of the ship. Pupil reactions, ocular movements and eye-grounds were normal. Vision was reduced to the perception of a moving object held very close to his eyes, and only in a small space of each visual field down and in. For a day or two he had much headache. All tests for the detection of malingering were negative, and all efforts in this respect by careful watching day or night were without result. He had no tremor, was not apprehensive, at least did not manifest apprehension, although he must have heard the daily "abandon ship" bugle and the noise of the gun practice, and knew the vessel was in the danger zone. He was distinctly lacking in mental alertness, and would sit for hours at a time almost absolutely motionless. He stated that once before, following a blow on the head, he had been temporarily blind for some weeks. Examined by Lt.-Colonel Mosher, no otolaryngologic or sinus lesions could be found; the general examination was negative. Facilities for a Wassermann test were not at hand.

The condition remained absolutely unchanged until about four or five days had expired, when a faint veiling of the nasal and upper edge of the optic disks was visible, an appearance not previously noted. On reaching Brest the patient was transferred to a French hospital, where every facility for examination was available. Through the courtesy of one of the naval officers, at the expiration of a month or six weeks a report was sent, which briefly summarized was this: In spite of a negative Wassermann, specific infection was suspected. Although he had had on board of ship a vigorous course of mercury by inunctions, the mercury was now administered hypodermically. Slowly, sight began to return; at the time of the report he could read large letters with one eye, and had a vision of about $\frac{1}{10}$ in the other eye. Since that time no record of the final result has been obtainable.

This case is mentioned because it would appear that what must have been a retrobulbar neuritis, at least in all probability, presented in many respects the signs of a long-enduring type of functional blindness.

Not long ago opportunity was afforded for the examination of a soldier who had seen overseas service, and who was sent to the hospital for the purpose of determining whether grossly

defective vision of the right eye was dependent on a lesion, or was the result of a neurosis, and evidently the opinion had been formed that the neurotic element was predominant. In point of fact, however, careful focussing revealed a diminutive lesion in the macula, almost certainly a very small rupture of the choroid, and yet fairly expert examination prior to his advent in the army hospital on this side had failed to discover this lesion.

Lagrange[1] makes reference to soldiers with loss of central vision without visible lesions in the macula in association, for example, with bruises of the face, and insists that they must not be considered as malingerers, explaining the central scotoma by the existence of disorders which are not revealed to the ophthalmoscope. In like manner, it may be stated that some of the cases of greatly defective vision in patients who have been classified as "shell-shock" really had a physical basis for the loss of sight, and it behooves the examiner to be painfully conscientious in his examination before disregarding the possibility of organic ocular lesion, even in the presence of the general symptoms of a neurosis. There is, of course, no reason why the two should not be combined.

(*b*) *The Visual Field Phenomena.* Following the teachings of the Charcot School, it was for a long time definitely believed and stated that the essential characteristic of the visual field in hysteria is *concentric contraction*, which is evident at the beginning of the examination and is not produced by repeated measurement, and that the amount of reduction varies from a slight contraction to such extreme restriction that the most peripheral circle is just beyond the fixing point.

Sometimes the field was noted to have a *tubular character*—that is, the contracted visual field maintains the same size, no matter at what distance from the examined eye the point of fixation is placed. (Fig. 1).

A constantly recorded variation consisted in the fact that the red field was the last to be affected, with the result that its extent exceeds that of blue, and becomes the most peripheral of the color circles. Occasionally charts of visual fields were produced where red was noted to be the most peripheral color

[1] *Atlas d'ophtalmoscopie de Guerre*, 1918, p. 17.

of the entire field. This is the so-called *inversion of the color field* (Figs. 5 and 6).

As is well known, these visual field phenomena in hysteria are, according to Babinski, due to suggestion. If suggestion can be eliminated, he maintains they do not develop, and Morax, at first impressed as most observers were, with the significance of the retracted field of vision in hysteria, later adopted Babinski's views, and found that if suggestion was eliminated in the examination, this so-called hysteric contraction was not produced. Believing that it is impossible to avoid suggestion during ordinary perimetric examinations, he relies upon simpler methods, taking the field with the aid of outstretched fingers or other familiar objects.

Hurst and Symns[1] state that they have never seen patients with hysteric symptoms, apart from hysteric amblyopia, who spontaneously complained of disabilities resulting from a narrowed field of vision. When, however, the perimeter was used, the patient not infrequently described inconvenience on account of the limitation of his peripheral vision. Examination of numerous soldiers with various forms of war neuroses, all of whom were abnormally suggestible, never determined the presence of contraction of their visual fields until they were tested with the perimeter, which invariably resulted in the suggestion of a narrowed field, however carefully it was used. In the light of our present-day knowledge, there is no question that too great stress has been laid on concentric contraction of the visual field and inversion of the color lines as a stigma of hysteria, and I overemphasized these phenomena in my article on the Neuroses and Psychoses[2] written fourteen years ago, and endeavored to make distinctions between hysterias and neurasthenias based upon visual field examinations which were not justified, because I did not sufficiently realize, as many physicians at that time did not realize the potent influence of suggestion. None the less these examinations are interesting and valuable in the study of such cases from the very fact that they demonstrate, or help to demonstrate, the presence of an

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[1] *British Journal of Ophthalmology*, vol. iii., No. 1, January, 1919, pp. 17–21.

[2] *The Eye and Nervous System*, edited by Posey and Spiller, 1906, p. 614.

abnormal nervous mechanism, which permits the ready acceptance of suggestion.

Hurst and Symns have made some very interesting observations on spiral fields among war neurotics. It will be remembered that von Reuss[1] described what he denominated the *fatigue spiral field*, which was thus produced. The first field having been already taken, the point at which the test-object in the second trial appears in the visual field on the horizontal meridian, for example, lies nearer to the center, and this is also the case in all meridians. When the examiner begins for the third time, the point of appearance of the test-object lies still nearer to the point of fixation, and so forth, until further contraction can no longer result and the later points of appearance of the test-objects coincide with the earlier ones. If all of these points are connected, a spiral line is formed which ultimately terminates in a closed line. Similar fields have also been described by Straub and Fuchs. Von Reuss was quite convinced that spirals were not more frequently observed because the search for them had not been an accurate one.

Writing on this subject, Hurst and Symns say: "If the examination was continued after the first field was marked out, a spiral field was always obtained, identical with that which has hitherto been regarded as a stigma of hysteria.[2] We believe that the reason why a spiral field of vision, which is the natural result of continued suggestion, has not been found in a larger proportion of hysteric cases, showing a narrowed field of vision, is simply because it has not been looked for, the examiner being content when he has marked the limit of vision a second time in each direction. It has generally been taught that a spiral field of vision is a result of fatigue, and it has even been stated that it is more frequently a symptom of neurasthenia than of hysteria. We have found that this is not the case, the inward spiral, which has hitherto alone been described, being a result of the method employed in using the perimeter. We have found that an outward spiral is always

[1] *Das Gesichtsfeld bei functionellen Nervenleiden*, 1902.

[2] von Reuss was of the opinion that his spiral field was not especially an hysteric phenomenon, but belonged to the visual field abnormalities which could be developed in neurasthenic patients.

ILLUSTRATING DR. G. E. DE SCHWEINITZ'S ARTICLE, "CONCERNING THE OCULAR PHENOMENA IN THE PSYCHONEUROSES OF WARFARE."

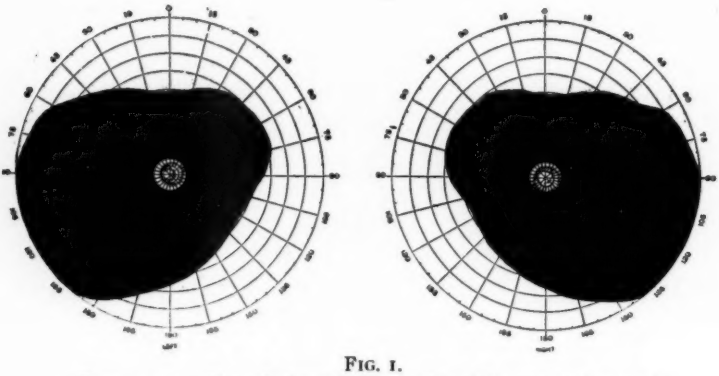

FIG. 1.

FIGS. 1 to 4. Hysterical amblyopia lasting eight months (see text). FIG. 1, typical tubular field. FIGS. 2–4 show gradual increase in size of field, easily brought about by suggestion.

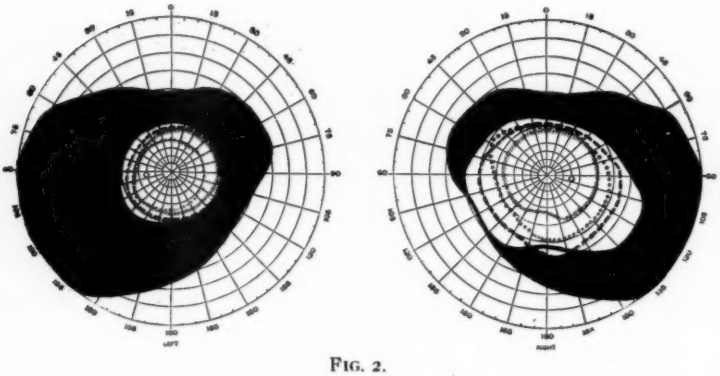

FIG. 2.

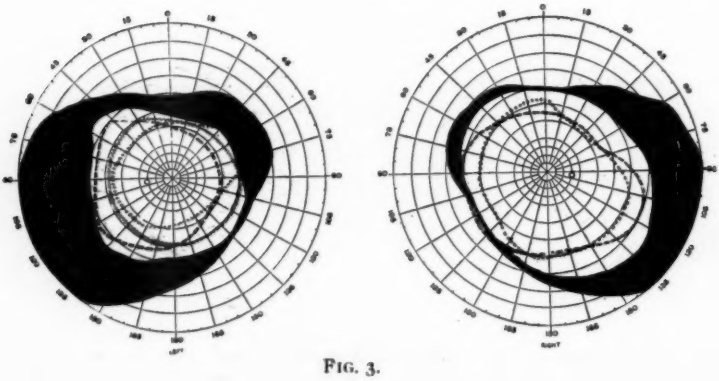

FIG. 3.

ILLUSTRATING DR. G. E. DE SCHWEINITZ'S ARTICLE "CONCERNING THE OCULAR PHENOMENA IN THE PSYCHONEUROSES OF WARFARE."

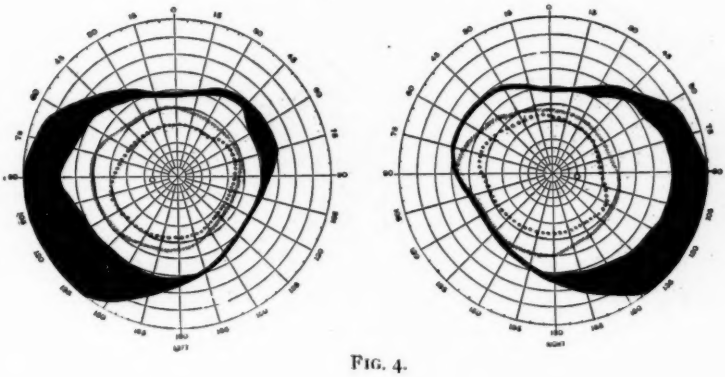

FIG. 4.

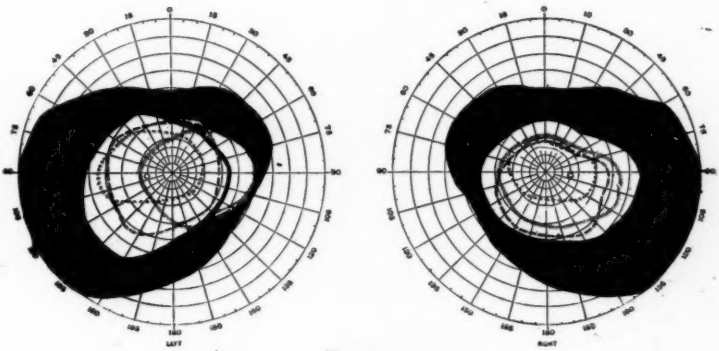

FIG. 5.

War shock and hysteria. Familiar contraction of field and partial inversion of color lines. Patient highly suggestible, V. $\frac{20}{L.}$

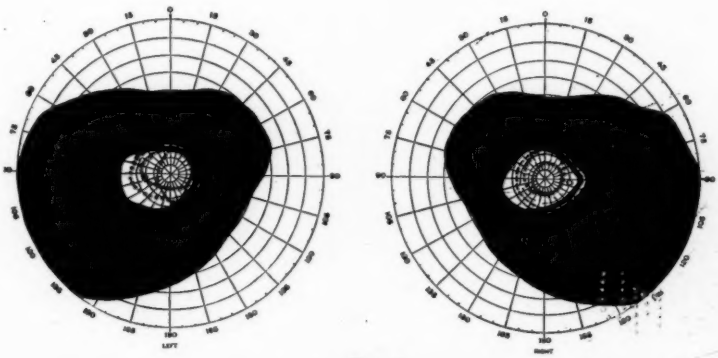

FIG. 6.

War shock and hysteria. Concentric contraction and color inversion. Note that red occupies in right field the smaller area.
Patient highly suggestible.

obtained instead of an inward one if the white disk of the perimeter is moved outwards instead of inwards, as is commonly done. We have in this way even produced an inward spiral for one eye and an outward one for the other, or an inward spiral one day and an outward spiral another day, with the same eye" (Fig. 7).

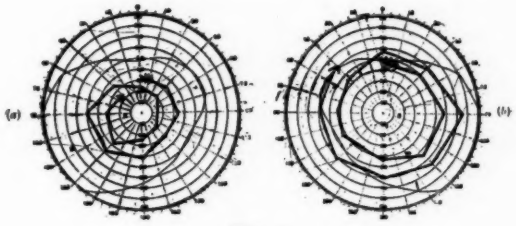

FIG. 7.

It would seem that the so-called tubular field as ordinarily described has been but little if at all mentioned in the description of the visual field symptomatology of war neurotics. That it is often present and may readily be developed there is no manner of doubt, and I have numerous observations in this regard. It has sometimes been stated that a tubular field is more nearly a characteristic visual phenomenon among hysterics than other departures from the normal field of vision, and yet when one thinks about it, it becomes apparent that it is more easily suggested than any of the other types of field which have been mentioned, and as shall presently be shown on some of the charts, a very much contracted tubular field may be the first development of what may be called the return of vision after hysteric blindness (Figs. 1–4).

In summary, then it may be stated that almost always among those who suffer from what has been called "shell-hysteria," or, in other words, the hysteria which resulted from various forms of war shock, concentric contraction of the visual field, with and without inversion of the color lines, tubular fields, and spiral fields, as described by Hurst, are commonly observed and readily suggested. In addition to these were

other variations, particularly in the position of the color lines, although the fields themselves were not greatly contracted, and those types of fields, particularly in some of the psychasthenic cases which in civilian life have so often been developed during the examinations of those who in general terms are classified among the neurasthenics—fields that are often called the "retinal tire fields." It has not seemed wise or useful to attempt to distinguish between the field phenomena of those who appear to be purely hysteric and those who have developed a neurosis of the neurasthenic or psychasthenic type.

(*c*) *Color Blindness.* In addition to the chromatic aberrations in the visual field, classified under the general term of inversion of the color lines, a few cases of complete temporary loss of the color-sense have been recorded, therefore achromatopsias, and these without any material loss of form-sense, and associated with practically normal visual acuteness, as tested with type cards. An interesting case of this character is the following:

> A boy, aged eighteen, well educated, had the position of flag-boy on a transport, the duties of which he well and accurately performed. Suddenly one morning, when the ship was about entering the submarine zone, and the natural activities of ship life were exceedingly acute, he announced to the supervising officer that he was no longer able to distinguish the colors. It had been noted that he was apprehensive and restless for some little time before this announcement was made. He was immediately sent to the sick bay and examined. Functional testing of his eyes produced normal results in every respect, except that he was totally color blind. He was kept in the ward for a few days, and little by little apparently helped by reassuring statements which were made to him, not only in regard to the return of color perception, but to the safety of his position, his ability to recognize the colors returned and was ultimately entirely reëstablished.

Hysterical achromatopsia, using the term originally announced by Galezowski, is characterized by the patient's inability to distinguish any color, although he perfectly recognizes the outlines and shapes of objects. It has been well said, by whom I do not remember, that everything appears like a sketch in India ink. It has, moreover, been declared that

although this hysteric color blindness may be complete, each color can be matched by a certain gray. In other words, the patient recognizes the equivalent gray tones, even more quickly than a normal individual. Such tests could not be made with the sailor whose symptoms have just been briefly described, nor am I able to state with accuracy the perception of which color he first acknowledged, but I think it was red, and this, if it is accurate, would correspond with the observation of Cruchet previously quoted.

When this boy was first examined it not unnaturally occurred to the observers that the temporary loss of color perception represented what has loosely been called "retinal exhaustion," but in the light of later experiences its explanation seems more likely to reside with that condition which is denominated an "anxiety reaction." Frederick W. Parsons,[1] referring to such reactions, writes: "Officers doubt their ability and worthiness to lead and have the responsibility of men. This is a transference of the emotion of fear for themselves to the possibility that injury may come to others." He refers to these cases as likely to prove stubborn, and not yielding to treatment as the gross hysteric symptoms do. The boy I have described had preceding his sudden loss of color perception a period of great anxiety, which increased as the transport entered, or was about to enter, the danger zone, and it seems not impossible that he overestimated his own responsibilities and feared that his duties improperly performed might bring the whole ship's company into great danger. The loss of color sensation, considering his occupation and his anxiety, was subconsciously adopted as the means to escape from the intolerable situation.

2. *Asthenopias and Anomalies of Accommodation.* Naturally many instances of prolonged asthenopia and weakness of the amplitude of accommodation have been observed, sometimes lasting for long periods and associated with foggy vision, as before described, especially if the subject has the background of an error of refraction, although this may be corrected. Spasm of the ciliary muscle producing a moderately high myopia, 4 D. or more, has been referred to, and this, as Morax and other observers have pointed out, may be the end-stage of

[1] *Loc. cit.*

blindness, or rather, the patient recovering from the blindness, may pass into a stage of ciliary spasm, which can be corrected with a concave glass, or dissipated by the use of a mydriatic, and also is sometimes associated with extreme convergence of the globes. These phenomena differ in no sense from those frequently observed among hysterics and also among those who are classified as neurasthenics, as they are encountered in civilian practice.

3. *Anomalies of the Iris Movements* (*Pupil Phenomena*). Although usually, even among those who are temporarily blind as the result of various types of war neuroses, the reactions of the pupil are normal, sluggish response to light stimulus has been frequently noted. Guillain and Barré,[1] discussing the anomalies of the reactions of the pupils which have resulted from the commotion caused by the explosion of large projectiles without external wound, investigated twenty-six cases of so-called shell-shock. In some they found mydriasis, the pupils failing to react either to light or to accommodation. In some the pupils were unequal, and either on one side or the other, or on both sides, were irresponsive to light impulse. They also describe a true Argyll-Robertson pupil, and refer to the so-called paradoxical light reaction. While these pupillary abnormalities were often transitory, lasting from three to twenty days, the period of their existence was occasionally longer, but ultimately the anomalies disappeared. They further make reference to certain rare cases of very long duration. In one man fifteen months after the shock the pupils were still unequal and reacted only sluggishly to light. In another case one year after the shock, the reflexes were not well marked, and dilatation and marked hippus were noted.

It would seem from the description, especially as in six of their cases there was a xanthochromatic cerebrospinal fluid, that there must have been cerebral hemorrhage, and the authors suggest that some of the pupillary phenomena may have been due to the products of hæmolysis or the presence of clots at the base of the brain. They also suggest retinal commotion as a possible cause, and even commotion of the ciliary nerves under the influence of the explosive shock. It will there-

[1] *Bull. Acad. de Méd.*, par., 1917, i., xxviii., pp. 158–159.

fore be seen that these pupillary phenomena do not belong, except perhaps those in which there was a temporary sluggish reaction, to the symptoms of a neurosis, or, in other words, that they had a very definite physical basis for their development. Such, too, must have been the explanation of the pupillary immobility and abolition of accommodation and convergence which has been described by Bergyl, and which he himself ascribes to the result of a cerebral concussion.

4. *Anomalies of the Eyelid and Exterior Eye-Muscle Movements.* As is well known, in the studies of hysteria in civilian life mention is usually made of a certain number of cases of so-called hysterical palsies of the ocular muscles, which Binswanger maintained indicated a defect of the associated lateral movements, or a motor insufficiency of certain muscular movements closely connected with psychical processes. It would seem, if they occur at all, that there is an apparent paralysis of movement and not of the muscle supplied by a given nerve. In those cases of so-called shell-shock coming under my own observation I never noted any phenomena which would belong to this group.

Extreme convergence of the visual axes in association with spasm of accommodation has been mentioned. Descomps, Enzière, and Mère[1] describe a convergence of the eyeballs immediately after rotary tests have been made in individuals who have been shell-shocked; one eye may converge more than the other. The convergence lasts from eight to sixty seconds. They also speak of functional or organic palsies of the eyes. No explanation of these phenomena is given.

True nystagmus must have been exceedingly rare.[2] Very frequently nystagmoid movements could be developed in forced rotation of the eyes in the lateral directions. A curious speech defect was evident in many of the war neurotics, not exactly a stuttering, but a repetition of a single word, or brief sentence; for example, the soldier would say: "I was shocked, I was shocked, I was shocked, I was shocked, in the, in the,

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[1] *Bull. et mem. soc. méd. des hôp. de Par.*, March, 1918, pp. 385–389.

[2] J. Mitchell Clark, *Bristol M. Chir. J.*, 1916, xxxiv., 49–72; also Ruossy and Lhermith, *The Psychoneuroses of War*, London, 1918, edited by Turner.

in the, in the, Argonne." Sometimes these repetitions were many in number, half a dozen or more, before the final word of the sentence was reached. Almost always there was an associated trembling of the lips and general tremor, and almost invariably, if these patients were made to turn their eyes sharply to the right or left, a jerking nystagmic movement was developed. In other words, it was a species of tremor.

Moreau[1] has written a paper on cases of nystagmus in concussion. In one case, for example, the soldier was shocked by the explosion of a large shell; coma followed; there was no external wound. Nystagmus resulted, the oscillations varying from 100 to 140 a minute. In another case, in addition to the nystagmus (the patient had been buried by the explosion of a shell, although there was no wound), he also had marked clouding of vision. The nystagmus appeared immediately after the trauma and had not changed. No other ocular defects were found. He does not attempt to give an explanation of the phenomena.

Of the eyelid peculiarities, blepharospasm, already referred to, was most common, sometimes clonic and sometimes tonic, and often in association with gross visual defects, as well as photophobia, this photophobia usually associated with a mild conjunctivitis, especially if at the time of the accident sand or smoke, or other irritating agent, had gotten into the eyes. The combination of photophobia, blepharospasm, with ciliary spasm, amblyopia and contracted fields, Coutela[2] denominates the "syndrome commotionel oculaire."

5. Exophthalmos has been noted among the war neurotics. In one case I observed the condition was marked, steadily increased for a few days, and the soldier's gait resembled that of cerebellar ataxia. Babonne and Celos[3] report two cases of mild exophthalmic goiter, which developed shortly after shell-shock. In one there was definite exophthalmos, in the other it was only slightly present, and nystagmic movements appeared in extreme rotations of the eyes.

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[1] *Ann. d'ocul.*, Paris, 1918, clv., p. 233.

[2] *Loc. cit.*

[3] *Bull. et mém. de la soc. méd. des hôp. de Par.*, xxxiii., No. 19–20, June 1, 1917.

Lortat-Jacob and Hallez[1] have recorded the case history of a young soldier, who suffered from shell-shock without external injury. After an initial asthenopia, he developed about five weeks after the shock a pure paralysis of the left sympathetic—left miosis, narrowed palpebral fissure, enophthalmos, and false ptosis. The fields and eyegrounds were normal. X-ray of the cervico-dorsal region was negative. Although organic cause for this condition was not discovered, it is difficult to believe it did not exist.

A word may be said in regard to the physical characteristics of the patients who suffered from so-called shell-shock, remembering that shell-shock is now used as equivalent to a neurosis, because many of the subjects never heard the sound of a bursting shell, but none the less had all of the symptoms of those who had been exposed to concussion from this influence, although they were not themselves wounded. It is well known, to use the words of an eminent neurologist, that the neuropathy which we term hysteria is expressive of a biologic inferiority, and in many studies that have been made among the subjects of the war neuroses the majority of the patients have shown a neuropathic tendency or inheritance. Moreover, it was often possible to obtain a neurotic family history, including insanity, epilepsy, alcoholism, and general nervousness, and the neuropathic constitution of the patient himself was frequently demonstrated. All this side of the question has been elaborately discussed by many neurologists both here and abroad, and an excellent paper on this subject has been written in our own country by Dr. Francis X. Dercum.[2]

It is evident that these war neuroses do not differ from the peace neuroses in their symptoms and evolution except in the association of the war coloring. The paper has not been burdened with long case histories, but the charts of vision may be interesting, and represent studies that were made in the U. S. General Hospital No. 30, at Plattsburg Barracks, and for the charts and help in this regard I am indebted to Captain Julius Newgord, Chief of the Eye, Ear, Nose, and Throat Department of that hospital. Only a few

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[1] *Bull. et mém. soc. méd. des hôp. de Par.*, 1918, 3 s., xlii., pp. 311–314.

[2] *Archives of Neurology and Psychiatry*, 1919, vol. i., pp. 65–76.

of the numerous fields which have been charted are reproduced. Others are similar and represent various types of visual field disturbance which have been referred to in the paper.

FURTHER EXPERIENCE IN THE OCULAR FUNCTIONS OF AVIATORS.[1]

By Colonel W. H. WILMER, M.D., M.C., U. S. A. (Discharged), Washington, D. C.

INCREASED experience in the Air Service in France deepens the conviction that the original ocular requirements for entrance into the Aviation Corps of the United States are none too strict, even though they do demand a standard of normality. History in all activities of life is replete with tributes to the "masters of fate" —those who have "made good" in spite of, or by reason of, physical handicaps. Such men have one's deepest admiration; but their forte, as a rule, is not in the air.

One of my early experiences in the A. E. F. was sitting on an accident board convened to consider the cause of death of two pilots from a collision in the air. The evidence brought out the fact that the student responsible for the accident had been disqualified in the United States on account of imperfect sight. In training he had passed through several fields until he reached the one where acrobatics were taught. The other pilot, an excellent flier, was just finishing his turn and was coming out of a vrille preparatory to landing. By virtue of the rules of the field and his "dead stick" he had the right of way, but the student with poor sight ran into him without seeing him and both were killed.

The great advance in the airplane, the increase of speed, facility of acrobatics, height of "ceiling," and the diversified duties of the flier have led to marked specialization in the air.

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[1] Read before the American Ophthalmological Society, June, 1919.

Before considering the ocular requirements of the aviator it might be well to speak of the fast-shifting types of air work that existed when the armistice was signed.

Types of Fliers.—The day chasse, or scout, pilot is the type of flier which is always suggested to the public mind when the word "aviator" is used. He is the "birdman" and the "hawkman" of the press. His duties are various. He must fly to any height, changing altitude instantaneously. It is his duty to protect his own bombers and observers on their special missions. Lieutenant Rath aptly calls him the "mine sweeper" of the air. His altitude varies from "ground strafing" to the limit of the plane's ability to climb. He has to keep a sharp lookout in the skies and in all points of the compass for friendly or hostile planes. A spot in the sun neglected may develop into a plane to be fought.

The night chasse pilots, so far, have not proved to be of great military value. While pursuing the enemy, they were often shot down by their own barrage, as instanced by the last air raid upon Paris when many French machines were lost.

The observer is of such importance that Colonel Reille, the able French artillery officer, says: "The principal rôle of aviation is not in dropping bombs, but in observation. The flying machine should not be considered so much as one of the arms of the artillery as one of its eyes—and that eye the better one. The bringing down the enemy's plane blinds his artillery." Richthofen, the German flier, says in his book: "Frequently a photographic plate is more valuable than shooting down a squadron." This type of flying officer is fast developing into a skilled specialist in artillery and infantry liaison with highly technical knowledge of radio, the making and interpreting of maps and photographs, visual reconnaissance with reports, and aerial gunnery. His work carries him to all altitudes, from dropping a message at 300 meters to a long reconnaissance at 6000 meters. In spite of all that must be seen on the ground, when he is near the enemy's line, he can spend only one eighth of his time for this work—the rest of his time must be spent in looking for planes in the air.

Day bombing has been described by Lieutenant Rath as "artillery on wings." The objectives are in the immediate

rear of the enemy's lines, zone of activity, and strategic points far within the enemy's country. These distant flights are frequently of four to five hours' duration, and often at an altitude of over 4000 meters, to avoid the enemy's anti-aircraft guns. The targets are often large and well mapped out before leaving the aerodrome. But the bomber must be minutely familiar with the topography of all the country embraced in his mission. Likewise, he must be able to use his maps intelligently. One of our fliers working with the English told of an amusing incident of a very successful night bomber who, on a very beautiful day, went up for a "joy ride" and got lost. He was not accustomed to the topography in daylight.

The night bomber seldom flies higher than 2000 to 3000 meters, but he must be thoroughly familiar with every foot of ground back of his own lines in order to make a landing without really seeing, should that necessity arise. He must be familiar with the topography of the hostile country in order to recognize guiding landmarks. He must be able to recognize all roads, rivers, woods, vineyards, and towns, the last largely by their geometric formations. He must know the constellations and their positions on the compass. Moreover, he must constantly consult his maps and compass. The following contretemps, due to unfamiliarity with the section, is told by some French fliers: An expedition actually bombed Nancy instead of Metz, and finally capped the climax by landing in Luxemburg! Many night fliers have spoken of the very confusing effect of moonlight on the earth-mists, which are so common in France during certain seasons. All Allied fliers speak of the greater effectiveness of the enemy's searchlights, which leave one blinded for a long time.

The aerial gunner's work has now been taken over by the observer, who has added the use of the machine gun to his other duties.

The aerial navigator is a late product of the war evolved by the necessity of flying in foggy or rainy weather and at night. He directs the flight of his pilot by map and compass. So far there are very few thoroughly trained aerial navigators.

The ferry pilot flies the machine from a central station to some aerodrome near the front, so he does not have to consider the questions of combat or of altitude. In the British

service the ferry pilot usually flew the planes across the Channel.

In the lighter-than-air ship the altitude is usually not over 300 meters, and the landing does not require the fine adjustment of sight and judgment of distance.

In the captive balloon the height is usually not over 2000 meters; and while good sight is of great value, the observer has little responsibility in landing, even when he has to take to his parachute. In the free balloon, however, the finest ocular adjustments are necessary.

In regard to sea planes, Major McCombs, who has had much experience in the matter, feels that the pilot should have good muscle balance, stereoscopic vision, and night sight. He says: "The level of the water is difficult to judge, especially when the weather is very calm, and at night." The "ships" are slow to answer the controls, and heterophoria is a common cause of bad landings.

General Considerations.—Color plays a most important part in the success of all types of fliers. On all maps generally used by observers, the woods are green, rivers blue, roads yellow, railroads black, and towns brown. These maps are used for spotting important objects. Sky rockets, with a parachute, are white, red, or green. And cartridges, with and without parachutes, are of similar colors. Bengal flares, which are used in woods and heavy underbrush, are red and white. The aerodromes use red and green or white lights for homecoming planes, while the planes themselves carry a red light on the port and a green light on the starboard side. In a "dog fight" fliers of great experience state it is necessary to recognize the colors on a machine in order to avoid the possibility of shooting down a friend. In artillery work the sense of color is necessary to detect false roads, trenches, and guns which have been camouflaged by colored screens, trees, etc. Infantry contact is one of the most trying pieces of work that an aviator is called upon to do. He must be able to recognize, in addition to everything else, the colors of the various uniforms. An observer tells of a pilot who flew three times over a body of troops before he felt it safe for the machine gun to be used. He had poor color vision, and his final decision was made only when he recognized the enemy helmets. All types of fliers

over land are liable to have to select quickly a place for a forced landing. In this connection Captain S. J. Allen, R. A. F., states that good color vision is necessary to detect differences of color on the ground. A light field indicates stubble; a dark-green field, grass, or wet and marshy ground; dark-green stripes running across fields, water or ditches; yellow, sand; and rough brown spots, bumps.

Sight.—The value of good sight is very tersely expressed by one of our very successful fliers at the front: "Men with poor vision do not come back." Major McCudden, R. F. C., graphically describes the unseeing pilot: "I shall never forget how that Fokker looked on the 2 C's tail, while the British pilot, calmly flying straight, not looking behind him at all, was no doubt thinking of Blighty, home, and beauty." The increase of vision by practice is emphasized by an American Ace: "I twisted my neck about so continuously, searching the sky for enemy planes, that the muscles of my neck have become enlarged. Although my sight has always been perfect, I improved very markedly my power of being able to quickly pick up the sight of a plane." While visual acuity is a most valuable asset to every type of flier, it is of less importance, relatively, to the day bomber, to the night bomber, and to the aerial navigator. In the case of the former, the targets are large; with the second, rod vision is more important than that of the cones; in the third type, glasses could be worn with comparative safety.

Should some ocular error become manifest in a pilot who is good otherwise, the error should be carefully corrected, preferably having the correction ground in his goggles. The pilot should, however, be carefully advised of the facts that the goggles might be blown off, be broken, or become fogged or soiled with oil or water.

One-Eyed Men.—All experienced men with whom I have talked agree that a one-eyed man should not be admitted into the Aviation Corps. However, when a successful combat pilot loses an eye, the question becomes an important military one, and the matter is now under consideration by the British Research Committee. The objections to returning him to duty are based upon the facts of a diminished field of vision, and the impairment of the ability to judge speed and distance

which causes difficulty in landing. The visual field is of lesser importance, owing to the nature of the work (most aptly described "rubber neck") which keeps one moving his head in all directions in search of planes. The difficulty in landing is more serious. It is recognized that some men cannot be trained to use one eye. On the other hand, a number of one-eyed pilots in the British Service were salvaged for their country. However, the gradual returning ability to take off and to land could be tested with a fast ship at the aerodrome. Professor Rivers, of the British Research Committee, in a personal conversation, laid great stress upon the economic value of the training, judgment, and experience in seeing of the combat pilot. According to a British authority, one R. F. C. cadet out of four reached the air over the enemy's line. In our service approximately one half of the observers and one third of the pilots got to the front.

The first few trips over the line are the critical ones. Other considerations are: the length of time it requires to make an aviator, that all good fliers are not good in combat, and that an aviator with perfect sight has to learn to use it understandingly.

Captain Rickenbacker, the foremost American Ace, telling of his first trip over the enemy's lines, says: "Major Luftberry asked what had been seen; but we both repeated, as easily as we could, that we hadn't seen any other aeroplane in the sky. 'Well,' said Luftberry, 'one formation of five Spads crossed under us before we passed the lines and another went by about fifteen minutes later and you didn't see them, although neither of them was more than five hundred yards away!'"

Color Vision.—The various activities in which the recognition of colors plays an important part have been mentioned. It is of great help in following the topography of the country in all types of fliers. However, if a successful color-blind pilot is discovered in classification, he could be used as an instructor, ferry pilot, or a night bomber, if only white lights were used at his aerodrome. Major McAlester, who was for a while stationed at the observers' school at the Second A. I. C., recommends very strongly the necessity of taking the color fields as well as the central color sense.

Muscle Balance.—Good muscle balance has been considered of great importance by those who have thoroughly studied the subject. Halben, in 1914, laid emphasis upon the danger of the laming of an eye muscle, thus producing a false projection and a disturbance of orientation. That the great importance of good muscle balance has been recognized is shown by the fact that a school of heterophoria has been established in England under the supervision of Major Clements. Here many pilots who have been unsuccessful in training have been salvaged by his painstaking work. During the period from August, 1917, to July, 1918, 84.5 per cent. of the officers turned down for bad landing were successfully treated by training the ocular muscles. In two subsequent groups 50 per cent. were successfully treated in one group, and 92.8 per cent. in the other. For ocular training Major Clements uses largely the Worth Amblyoscope. The importance of this subject in our service has been emphasized in the ophthalmologic departments of the medical research laboratories in this country and in France. In addition to well-balanced muscles, strong convergence, and accommodation, we have felt the necessity for measuring the rapidity of accommodation in changing the point of fixation, and for comparing the records of the two eyes. At the last meeting of this Society Professor Ferree read a most valuable paper upon "The Inertia of Adjustment of the Eye for Clear Seeing at Different Distances." Major Berens has done much work upon an apparatus to make these tests, and also upon other instruments for studying monocular and binocular parallax in the judgment of speed and distance. Treatment of these muscular weaknesses consists in removing all underlying causes, in rest, in muscle exercises, and, in rare instances, in operative procedures. The wearing of prisms is risky.

Stereopsis.—The value of stereoscopic vision has been questioned, owing to the recognized fact of the predominant eye, and the fact that a few men with one eye, and some with poor stereoscopic sight, have been successful fliers. However, in our opinion, good stereoscopic vision is of great value in the judgment of distance in making a landing. It is also of value in studying stereoscopic plates. The cards with stereoscope as used in the selection of the flier take up very little space and

they are easily and quickly used. However, the most practical test that I have seen is the one used by Professor Spearman. In brief, it consists of two fixed vertical outside wires, a middle movable wire attached to a millimeter scale. This wire is attached to an endless cord running over a pulley at either end. The background is a milk glass lighted by electricity that can be increased or diminished. The observer sits facing the wires at a distance of ten feet. He looks through an aperture and moves the central wire back and forth until it seems to be on the same line with the two outside wires. He is allowed twenty seconds to make each reading, and his average is taken from six readings. His accuracy is recorded on the millimeter scale. The method of making this test can be improved by making shorter the period allowed for observation, by reducing the twenty seconds to from two to five seconds. In Professor Spearman's latest apparatus, the comparative test objects are formed by the edges of two pieces of milk glass set at an angle. Professor Spearman has found correlation between success in flying and good stereoscopic vision taken by this test.

Retinal Sensitivity.—Study of the various methods of testing retinal sensitivity impresses one with the fact that no "short cut" to accurately testing this function has been devised. Our Italian allies use a very good test of the contrast sensibility. The test-object is a series of incomplete circles of different sizes on a background in which there is an increasing diminution in the shade difference between the circles and the background. There are a number of more accurate tests, but they require from one to one and one half hours for each subject. Professor Spearman has a new apparatus. He first produces a uniform bright adaptation by having the subject face a white screen illuminated by a 1000-watt lamp. He is then kept in complete darkness for two minutes before the testing begins. He then tests the threshold sensitivity by throwing different stimuli upon the screen with his "night vision box." At the Medical Research Laboratory, Mineola, L. I., Captain Cobb has devised an excellent "adaptometer" which he has described in full. He points out facts that have already much impressed us when considering the classification of the night flier, and our want of exact knowledge concerning the photometric value of objects to which he is exposed. One

has to consider the varying light value of stars, clear moonlight, misty moonlight, reflections from roads, rivers, towns, and the "blinding" effect from tracer bullets, lights at aerodromes, sky-rockets, cartridges, flares, bursting shells, and searchlights. Practically, it would seem that one who has a good average speed of adaptation with an average recovery from exposure to light for a brief period would make a safe night flier, from the visual standpoint. An accurate test of this type requires an hour or more, but in classification of fliers for night work it is well worth this expenditure of time and care. McCudden, speaking of a pilot flying at night, says: "He left the ground in the dark to fly twenty miles across France to an aerodrome, and as soon as he was off the ground he flew through the side of a house. The only thing that was undamaged was himself."

Simple visual reaction time, which is so important to the acrobatic flier, is not of so much importance to the combat pilot unless associated with cool decision and accurate muscular coördination. Richthofen, who was credited with bringing down eighty Allied fliers, says in his work, *The Red Battle Flier*: "It followed that the victory would accrue to him who was calmest, who shot best, and who had the clearest brain in a moment of danger. We have lost many good fighting pilots through their getting excited and dashing headlong into an unequal combat." The most successful fighter is not the one who fires the first shot, but the one who carefully lines up his sights upon the enemy and who downs him with the first bursts from his machine gun. In other types of fliers a strong physique is more important than a rapid reaction time, on account of the physical strain to which they are exposed. The French authorities give the average visual reaction time as $\frac{19}{100}$ seconds. The average of these tests made in the laboratory in France with the d'Arsonval chronoscope is: students, $\frac{19}{100}$; monitors, $\frac{17}{100}$; testers (among whom there were some remarkable stunt fliers), $\frac{18}{100}$; American fliers from the front, $\frac{20}{100}$ and French fliers, $\frac{21}{100}$.

CONCLUSIONS.

1. Absolute normality of the eyes is one of the greatest physical assets that a flier can possess.

2. Affections of only passing inconvenience on the ground are serious in the air, such as scintillating scotoma, muscæ volitantes, photophobia, epiphora, heterophoria, and for the night flier, poor dark-adaptation.

3. A successful combat pilot with trained air vision who loses one eye may, during the exigency of war, be seriously considered for a return to flying status, under certain conditions previously mentioned. This, however, should be considered only when the confidence is unimpaired and there is keenness to get back.

4. In classification, a cycloplegic should be used and the fields for form and color taken and recorded.

5. The regular eye reëxamination of the flying officer should be made every two months, at least.

6. The simple visual reaction time is of great value to the chasse pilot if associated with cool determination and caution.

In spite of the painstaking work of our Allies and of our own laboratories and the splendid record of this work, should a questionnaire be framed asking what was the most important lesson learned in the A. E. F. concerning the ocular problems of aviation, I would answer, "How much there is to learn and how little is known!"

A CASE OF KERATITIS PROFUNDA (OR DISCIFORMIS?) WITH MICROSCOPIC EXAMINATION.[1]

By F. H. VERHOEFF, M.D.

(From the Massachusetts Charitable Eye and Ear Infirmary.)

(*With two illustrations on Text-Plate XIII.*)

ALTHOUGH it is possibly somewhat uncertain whether the case I have to report should be classified as one of keratitis profunda or of keratitis disciformis, our knowledge regarding the true nature of either of these conditions is so indefinite that the histological findings in my case would seem to be of considerable importance. The case occurred at the Massachusetts Charitable Eye and Ear Infirmary on the service of Dr. F. M. Spalding to whom I am indebted for the privilege of reporting its clinical features.

CASE.—Benjamin, H. N., aged 65, stableman. Admitted to the Massachusetts Charitable Eye and Ear Infirmary, January 2, 1915. The patient states that his left eye has been affected for the past three weeks. The vision has become blurred, and the eye has felt irritated, but there has been no actual pain.

Examination.—Right eye normal, vision $\frac{20}{20}$, tension 17*mm* (Schiotz). The left eye is considerably congested. The cornea is markedly hyperæsthetic, has a distinctly grayish hazy appearance, with general unevenness of the surface, probably due to œdema, but it does not stain with fluorescin. The anterior chamber is normal in depth. The pupil, normal in size, reacts poorly to light. The iris markings are slightly blurred. The corneal condition obscures view of the fundus.

[1]Read before the American Ophthalmological Society, June 16, 1919.

Tension 35*mm* (Schiotz), vision, fingers at 1½ feet. Solution of pilocarpine nitrate 1% ordered to be instilled three times daily.

Jan. 10th.—Left eye painful and more congested. Pupil contracted and irregular. There appear to be some deposits on the posterior surface of cornea.

Jan. 11th.—Atropine sulphate 1% substituted for pilocarpine.

Jan. 13th.—Pupil dilated and irregular from posterior synechiæ.

Jan. 17th.—Tension lower. Pupil half dilated. Deposits on posterior surface of cornea persist.

Jan. 24th.—Less pain. Cornea still quite hazy.

Jan. 31st.—Some blebs on cornea as in bulbous keratitis. Tension only slightly elevated. Some pain at times.

Feb. 7th.—Very little pain. Cornea roughened and hazy. Moderate congestion.

Feb. 21st.—Tension normal.

Feb. 25th.—There are two spots in upper part of cornea that stain with fluorescine. Very little pain. Tension normal.

Feb. 28th.—Some superficial vascularization of cornea above. Pupil moderately dilated.

Mar. 21st.—Eye more congested. Cornea very hazy. Enucleation advised.

Mar. 22d.—Enucleation of left eye under local anæsthesia by Dr. Lancaster, eleven weeks after onset of keratitis.

PATHOLOGICAL EXAMINATION.

(3–2789.) Fixation in an aqueous solution containing formalin 10%, alcohol 54%.

Macroscopically.—The globe is normal in size and shape. The cornea is clouded by the method of fixation so that no details can be made out within it. Its surface is smooth and is covered with epithelium. There is a vascularized pannus all around, most marked above. The anterior chamber is slightly shallow, and contains a delicate serous coagulum. The lens is *in situ*. The filtration angle is everywhere free. The pupil is 3*mm* wide, and its margin is firmly adherent to the lens. The vitreous is normal. The retina and choroid are *in situ* and apparently normal. The disk is not swollen or noticeably cupped.

Histological Examination.—Fixation as noted above. Meridional vertical sections through most of the central portions of the cornea, and plane sections through the remaining central portion. Longitudinal sections through the

ILLUSTRATING DR. VERHOEFF'S ARTICLE ON "A CASE OF KERATITIS PROFUNDA (OR DISCIFORMIS?) WITH MICROSCOPIC EXAMINATION."

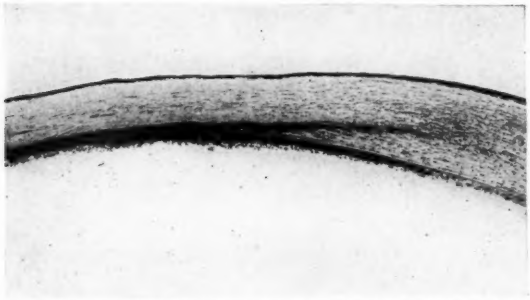

FIG. 1. Median vertical section of cornea showing half of affected area. (The other half presented a similar appearance.) The epithelium is intact but altered. The anterior layers of the central portion of the cornea are devoid of nuclei. In front of Descemet's membrane the corneal corpuscles have actively proliferated, forming a layer which rapidly widens out and disappears at the periphery. In the middle layers of the cornea some of the corpuscles show various stages of necrosis, others active proliferation. There is no infiltration with leucocytes. The endothelium is absent and the posterior surface of the cornea is coated with fibrin and leucocytes. Hæmatoxylin and eosin. Photo × 41.

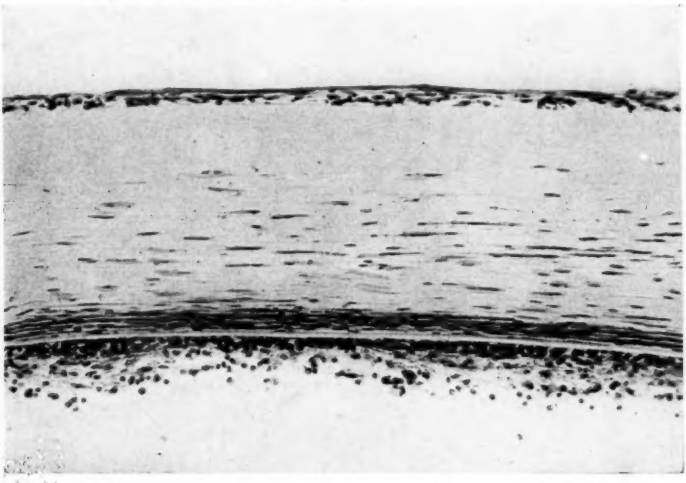

FIG. 2. Section of central portion of affected area of cornea under higher magnification. Hæmatoxylin and eosin. Photo × 150.

optic nerve nearly to the central vessels; serial cross-sections of the remainder of the nerve. Staining in hæmatoxylin and eosin and in a variety of other stains.

The most marked corneal changes involve a central area about 4.5*mm* in diameter (see Fig. 1). Here, in the anterior third of the corneal stroma, the lamellæ have become slightly hyaline in appearance and have lost their distinct outlines, while the corneal corpuscles have completely disappeared. In fact, no cells of any kind are present here (see Fig. 2). Posteriorly, the corpuscles become visible in small numbers, many of them, however, showing chromatolysis, pyknosis, or fragmentation of their nuclei, and others active proliferation. Just in front of Descemet's membrane, in a sharply defined layer about one seventh the thickness of the cornea, the corneal corpuscles are greatly increased in number, their nuclei are rich in chromatin, and many of them show various stages of amitosis or mitosis. At the periphery of the central area, this layer of proliferating corneal corpuscles extends away from Descemet's membrane and rapidly becomes broadened out and disappears. The corneal stroma shows no vascularization, and is almost free from leucocytic infiltration throughout, except near the limbus where there is slight infiltration with pus cells.

In this central portion, the cornea is reduced to about two thirds its normal thickness, probably owing to shrinkage and compression of the injured tissue resulting from the action of the fixing fluid employed. Bowman's membrane is everywhere intact. The epithelium is normal at the periphery of the cornea, but over the central portion, it is greatly altered. Here it is thinned, due to changes affecting the basal cells, the squamous surface layers being intact. The basal cells are shrunken and distorted, and their nuclei are often pyknotic. Many of the pyknotic nuclei are stretched out into irregular fantastic shapes. These changes are best seen in plane sections. In places there are small cystic spaces beneath the intact surface layers, containing discrete altered basal cells that have been cast off from Bowman's membrane.

Descemet's membrane is also everywhere intact. The endothelium is completely absent behind the central portion of the cornea, a stretch of 1*mm* of it remaining at the periphery below, and 4*mm* above. Behind the central area there is a layer of fibrin and leucocytes, about .04*mm* thick and 4.5*mm* in extent. Immediately in contact with Descemet's membrane the leucocytes consist almost exclusively of pus cells; the other cells enmeshed in the fibrin are chiefly endothelial cells, many of them containing pigment. Occasionally one of the endothelial cells is multinucleated. Many

fibroblasts are also seen, indicating that organization has begun. Towards the periphery the layer of fibrin ends rather abruptly, but considerable numbers of pus cells and small and large lymphocytes are adherent to the cornea all the way to the filtration angle. About 5% of the polynuclear leucocytes are eosinophiles.

In addition to the large central corneal lesion just described, two smaller spots evidently of the same general nature are encountered. The spots are similar in character, but the sections pass through the center of only one of them. The latter is about .75*mm* in diameter. Within it the corneal corpuscles beneath Bowman's membrane for a depth of three or four lamellæ show marked pyknosis and fragmentation, while those still deeper are greatly increased in number and their nuclei show various stages of amitosis and budding. In this vicinity the stroma shows a slight infiltration with pus cells. Over the center of this spot the epithelium is markedly altered. The basal cells have disappeared as a definite layer, and the surface layers are lifted up, leaving a cystic space filled with discrete cells. The latter have only a small amount of cytoplasm, possess small nuclei of various sizes, and seem to have been derived from basal cells that have been cast off from Bowman's membrane. Intermingled with these cells there are also a few pus cells.

The tissue of the limbus is highly congested and greatly thickened by infiltration with chronic inflammatory cells, chiefly plasma cells. Extending between the epithelium and Bowman's membrane from above for 2.75*mm* there is a pannus somewhat similar in appearance to a pannus degenerativus. This is actively growing and is richly infiltrated with chronic inflammatory cells. A similar pannus is beginning below. A few vessels are just beginning to push their way from the sclera into the deeper layers of the cornea.

The filtration angle is nowhere blocked by the root of the iris. Below it is filled with leucocytes up to the level of the end of Descemet's membrane, and also contains a small amount of fibrin. Pus cells predominate here, but there are also many plasma cells, lymphocytes, and a few endothelial cells. The spaces of Fontana are filled with similar cells. A few new formed capillaries are making their way over the surface of the ligament, some of them beginning to extend over the posterior surface of Descemet's membrane. The serum filling the anterior chamber contains scattered leucocytes—about six to twelve to the high power field.

The iris is considerably infiltrated with chronic inflammatory cells, chiefly lymphocytes, but is not highly congested. The infiltration is greatest in the region of the sphincter where it tends to assume a nodular character. Along the

anterior surface of the iris are numerous leucocytes, mostly lymphocytes, but almost no fibrin. There is annular posterior synechia 1*mm* wide. From the pupillary margin there extends a thin fibrous membrane over the surface of the lens, blocking the pupil. Over the central portion of this membrane there is a layer of fibrin in which a few leucocytes are enmeshed.

The ciliary body is almost normal, showing only a slight leucocytic infiltration. The retina and choroid are normal. The optic disk is possibly very slightly cupped. The central vessels, cut in serial cross-sections, are normal. The lens is practically normal, showing only slight cataractous changes at its periphery.

Bacteriological Examination.—Sections stained by the Gram method, the method for tubercle bacilli, and in carbolthionin, show no microörganisms in the cornea or elsewhere.

REMARKS.

This case was not seen by me clinically, and the clinical notes upon it were made by a house surgeon unfamiliar, naturally enough, with such rare conditions as keratitis disciformis and keratitis profunda. The clinical description, therefore, is not sufficiently detailed for a diagnosis to be made from it alone, but interpreted and amplified in the light of the microscopic findings it shows that clinically the cornea displayed a grayish circular opacity 4.5*mm* in diameter. Over this the epithelium was intact but presented a marked stippling of its surface, and on one occasion, vesicles. The margin of the opacity must not have been sharply defined, but was intensified by the zone of proliferating corneal corpuscles surrounding the main opacity. It is doubtful that this was sufficiently conspicuous clinically to form the intensified border described by Fuchs as characteristic of disciform keratitis. The thick layer of fibrin and leucocytes, however, on the posterior surface of the cornea had an extremely sharp peripheral outline, and may well have given a disciform appearance to the whole opacity as seen clinically. In addition to the central opacity there were two outlying superficial punctate spots, both of which were also seen microscopically. Both clinically and microscopically there was noted severe iritis with posterior synechia and deposits on Descemet's membrane.

From these facts it is obvious that this case was either one of keratitis profunda or of keratitis disciformis.

The opacity of the cornea was, no doubt, primarily due to alteration in the anterior layers of the cornea manifested microscopically by slight hyaline change of the lamellæ and destruction of the corneal corpuscles. Later it was greatly increased by the layer of proliferating corneal corpuscles in front of Descemet's membrane and by the thick layer of fibrin and leucocytes deposited on the back of the cornea. The changes in the epithelium in this case were most striking. Just how much importance to attach to them, it is difficult to determine, since the eye was removed under local anæsthesia and the cornea was exposed to drying and the action of cocaine for an unusual length of time. The distortion of the nuclei was almost certainly due chiefly to this cause. The other changes, however, were probably not artefact because they existed only over the affected portions of the stroma, namely over the central area and over the small punctate spots at the periphery. Moreover, I have never seen such changes in any other eye removed under local anæsthesia.

In the literature, no case diagnosed as keratitis profunda, and only two cases clinically diagnosed as disciform keratitis, have been examined microscopically, one reported by Hadano (1) the other by Meller (2). Hadano examined only a piece of tissue removed from the cornea by means of a sharp spoon, while Meller examined the entire eye. The findings in these two cases were so different that it is almost, if not quite impossible, to believe that the two cases represented similar conditions. Thus Hadano found that the small piece of tissue removed by him (he does not mention its exact size) consisted of a swollen mass of wavy interlacing bundles in which there was complete absence of inflammatory infiltration or tissue proliferation. Only a few nuclei were to be seen, and in the central area almost no nuclei were present. On the other hand, Meller found intense cellular infiltration with necrosis of the infiltrate and loss of corneal substance.

In my case, the microscopic findings were in accord with those of Hadano. The additional features found by me could not, of course, have been seen by Hadano, because he did not remove a sufficient thickness of corneal tissue to reveal them,

while the appearance of wavy bundles described by him is no doubt explained by the traumatism to which the tissue was necessarily subjected during its removal.

The possibility may suggest itself that the changes present in the cornea in my case existed in Meller's case but were masked by a secondary infection. Careful examination, however, of sections from Meller's case, which were kindly sent to me by Professor Fuchs several years ago, excludes this possibility, for in these sections there is no trace of the hyaline condition of the corneal stroma nor of the layer of proliferating corneal corpuscles which in my case walled off the central area from behind and also formed a peripheral zone around it.

As pointed out, my case was certainly one of keratitis profunda or disciformis. Meller's case was just as certainly not one of keratitis profunda, for the great density of the corneal infiltration as well as the relatively extensive loss of corneal substance excludes this possibility. If, therefore, we assume that disciform keratitis is a distinct entity, and that Meller's case was a true case of this condition, we must conclude that my case and that of Hadano were cases of keratitis profunda. I am, however, not prepared to make either one of these assumptions.

As a matter of fact I am convinced that the cases of disciform keratitis described in the literature do not represent a single condition. Disciform opacity of the cornea may arise from a variety of causes. As is well known, it may occur in hereditary syphilis where it probably is due to a metastatic infection of the cornea with spirochætes, it may occur as a type of ulcus serpens, it may result from infection with vaccine virus, as pointed out by Schirmer (3), it may occur in non-gonorrheal ophthalmia neonatorum due to infection with the streptococcus mucosus as I have myself observed. Probably it may occur as a form of tuberculosis of the cornea as suggested by Weeks (4), and as a result of unknown infections. Finally, it may occur as a complication of herpes cornea or as a result of trauma, in which cases it is probably neuropathic in origin as maintained by Peters, although Fuchs's view that here also it is due to some unknown infection has not been excluded.

Possibly the cases of keratitis disciformis originally described by Fuchs did comprise an entity, but his clinical de-

scription is not sufficiently exact, and probably no description based upon clinical appearances could be sufficiently exact, to enable other observers to identify the condition with certainty. Moreover, such cases are seen by any one observer at such long intervals that it is unlikely that the clinical picture could often be carried in mind from one case to another. In the clinical description of his case, Meller states that after a time the infiltrate presented a sharply defined margin, but he does not mention here the intensified border described by Fuchs as characteristic of disciform keratitis. He does, however, attempt to reconstruct the clinical appearance from his microscopic findings, but in my opinion he fails to do so successfully. One of the sections of his case in my possession passes near the middle of the infiltrate, yet it fails to show anything which would give the appearance of an intensified border. His illustrations likewise fail to do so. In two other ways also his case did not conform to Fuchs's description, namely, in that the density of the infiltrate was unduly great for the small size of the latter and in that the loss of substance was relatively large. For, from measurements made from the section referred to, and from the illustrations of Meller's case, I find that the infiltrate was only *2mm* in diameter and the loss of substance involved half of this area. Owing to the necrosis of the infiltrate Meller was unable to determine the nature of the cells comprising it. It seems to me, however, that I can identify many of the cells as endothelial phagocytes and to determine definitely, at least, that the infiltrate does not consist chiefly of pus cells. This is substantiated by the fact that almost no pus cells are approaching it from the periphery. From the foregoing considerations I conclude that Meller's case, although not one of keratitis profunda, was not a typical case of disciform keratitis as described by Fuchs, and that it was not due to tuberculosis or to vaccine virus, but probably to infection of the cornea with some unidentified non-pyogenic microörganism.

The term keratitis profunda has been used in a general way for many years to describe various forms of deep-seated keratitis, including that of hereditary syphilis, but so far as I can ascertain Fuchs was the first to restrict its use to a distinct clinical entity. In his latest textbook (Duane's translation) he makes the following statement in regard to the differentia-

tion of this condition from keratitis disciformis: "Keratitis disciformis has a certain resemblance to keratitis profunda, in which also a deep-seated gray, non-ulcerating cloudiness develops in the center of the cornea. But this is composed of gray striæ and specks and merges gradually into the transparent cornea. In keratitis disciformis, on the contrary, the opacity appears uniformly gray and only on strong magnification is resolved into very minute clear-cut, white, closely packed dots; moreover, it is very sharply demarcated from the healthy cornea by the gray circular line along its border."

Taken in connection with his detailed description of the two conditions, it seems to me that the points mentioned by Fuchs are not always sufficiently definite, and I therefore concur in the view of v. Hippel (5) that it is not always possible to differentiate the two conditions. In other words, I believe there are cases which present the essential clinical features of disciform keratitis but which are really of the same nature as keratitis profunda, and it is to this class of cases to which I believe my case and that of Hadano belong. This view harmonizes with the following statement made by me ten years ago:(6) "The facts that both keratitis profunda and keratitis disciformis occur most commonly after herpes zoster or trauma, that both may be associated with corneal hypesthesia and show outlying superficial punctate spots, impel me to believe that both conditions are essentially neuropathic, the minor differences between them being dependent on differences in the intensity of the nerve irritation."

The question now arises as to the indications the histological findings in the present case offer in regard to the cause of the condition, and as to whether or not these findings support the clinical evidence that keratitis profunda is neuropathic in origin. In the first place it is obvious that the central corneal lesion is due to some diffusible toxic substance arising in the anterior layers of the cornea. This is evident from the fact that the corneal corpuscles have been completely destroyed in the anterior third of the cornea and are progressively less injured from before backward, while next to the membrane of Descemet and at the periphery they have been stimulated by the weakened toxin into active proliferation. Likewise, the corneal lamellæ are most affected anteriorly. That this

toxin was of infectious origin is highly improbable. For it seems impossible for organisms to have existed in the cornea for eleven weeks without causing leucocytic infiltration of any kind in the affected area. It is true that highly virulent organisms often produce toxins of such intensity that the latter prevent leucocytes from reaching the site of infection but in such instances the area is always surrounded by a zone of leucocytes and the infected tissue undergoes necrosis and breaks down. In the present case, the corneal corpuscles were destroyed in the affected area, but the stroma was only slightly injured, while the cellular infiltration even of the surrounding cornea was insignificant.

On the other hand, the histological findings in the present case are in perfect accord with the theory of neuropathic keratitis advanced by me in 1909, and again in 1911 (7). According to this theory, as a result of an irritative lesion in the gasserian, or possibly the ciliary ganglion, impulses are sent backward to the nerve terminals in the cornea where they produce electrolytic changes leading to the formation of toxic substances. The latter then give rise to corneal lesions, chiefly superficial, which vary in character according to the intensity and duration of the nerve lesion and the distribution in the cornea of the nerves corresponding to it. Thus a diffuse lesion in the ganglion involving the nerve supply of the central portion of the cornea would give rise to toxic substances at or near the surface of the cornea which in diffusing backwards would produce the changes described. The associated iritis could be explained either by the action of these toxins on the iris, or by a simultaneous involvement of the nerves of the iris. The deposit of fibrin and leucocytes on the posterior surface of the cornea is easily explained by the destruction of the endothelium by the toxins diffusing through the cornea, just as are explained the mural thrombi that are formed in veins when the endothelium is injured. Had it existed sufficiently long, no doubt it would have undergone complete organization.

The only previous case of neuropathic keratitis of any kind, uncomplicated by infection, in which the entire eye was examined microscopically, was the case of superficial punctate keratitis reported by me in 1911 (7). The punctate spots in this case were situated just beneath Bowman's membrane, and

showed necrosis of the corneal corpuscles as in the lesions of the present case, but in addition were densely infiltrated with polynuclear leucocytes also in various stages of necrosis. The corneal lamellæ were only slightly injured and there was some proliferation of corneal corpuscles at the periphery of the spots. In both cases the epithelium over the lesions was altered but not destroyed. Aside from differences in size, therefore, the only important difference between the corneal lesions in these two cases consisted in the far greater leucocytic infiltration of the lesions in the earlier case. Three possible explanations for this difference suggest themselves: (*a*) That the leucocytes of the patient in the present case were less sensitive to the chemotactic influence of the toxic substances diffused from the cornea, although in both cases these toxic substances were the same in kind. (*b*) That in the first case the toxic substances were produced more rapidly and hence were more concentrated in their action. This is in accord with the fact that at the time of enucleation the duration of the lesions in the first case was about three weeks, in the present case, eleven weeks. (*c*) That early injury to the endothelium in the present case caused the diffusion of the toxins to take place chiefly into the anterior chamber. This is in accord with the fact that an abundance of polynuclear leucocytes were enmeshed in the fibrin on the posterior surface of the cornea.

Assuming that the present case was one of keratitis profunda it is obvious from the microscopic findings that this term is misleading. For, while the deeply seated changes in this form of keratitis are clinically the most conspicuous, it is obvious that the toxic substances which cause them arise at or near the surface of the cornea.

CONCLUSIONS.

Disciform keratitis may be produced by a variety of causes, and from an etiological standpoint is therefore not an entity.

Certain cases of disciform keratitis are of the same nature as keratitis profunda.

The corneal changes in keratitis profunda are due to the action of diffusible toxic substances arising near the anterior surface. The changes consist in alteration of the epithelium,

destruction of the corneal corpuscles and injury to the stroma in the anterior layers of the cornea, and proliferation of the corneal corpuscles behind and around the injured area. In addition to this, there is injury to, or destruction of the endothelium, and in severe cases, deposition of fibrin and leucocytes on Descemet's membrane behind the affected area. Leucocytic infiltration of the corneal stroma is conspicuously absent.

The microscopic findings in the present case strongly indicate a neuropathic origin for keratitis profunda.

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JUDGMENT OF DISTANCE WITH SEMAPHORES AND A SCREEN AT 100 METERS.

By HARVEY J. HOWARD, Captain, M. C., Medical Research Laboratory, Hazelhurst Field, Mineola, Long Island, N. Y.

(With two figures in text and one figure on Text-Plate XIV.)

SINCE aviation became a science the term "judgment of distance" or, as some will call it, "stereoscopic vision" has come to have a new bearing. It takes such a slight error in judgment, especially in landing a plane, in order to produce disaster that the subject quite naturally has aroused serious attention. To learn to fly is like learning to walk. It is a new experience and it takes time to adapt oneself to new requirements. But unlike learning to walk, one fall may end it all. For this reason and others anything that may be done to choose properly those who can meet the requirements and to eliminate those who are physically unable to meet them is worth while. In other words, it must be regarded as a select game, not open to all. This is even more true when we are called upon to deal with flying from the military standpoint.

There has been a doubt in the minds of some, which has extended into cocksure opinions on the part of others that certain tests applied to applicants for flying service are unnecessary. From the outset then any attempt to exclude men from the opportunity of learning to fly is looked upon in some quarters as an "outrage."

Confidence in oneself is a good trait, but it may lead to an overestimation of one's ability. For instance, if a man has always been defective in certain ocular functions, he has not had the opportunity to develop that conscious understanding

of what an individual with perfect ocular functions in comparison with himself can do. Therefore, he may be firmly convinced that he is "as good as the next man." It is a common experience to find an applicant trying to argue with and wheedle the examiner into "letting him by," when, *e. g.*, he cannot read $\frac{20}{15}$ or cannot show good stereopsis. For these reasons and others it is well for the examiner, first to be sure he is right, and then go ahead. He should have real convictions why certain men should be excluded from flying and he should have faith that the test he applies actually performs what it calls for.

If we as examiners are convinced that any test fails to measure up to the purpose for which it was intended, it behooves us to check it up with other tests or to discard it if something better is found.

The Problem.—In view of a somewhat widespread criticism of the hand stereoscope as a test for the judgment of distance, it was suggested that research be undertaken at the Medical Research Laboratory for the purpose of finding out, first, what the factors are that make men individually different in their ability to judge distance and, second, to devise an apparatus which would eliminate all irrelevant factors and test only the factor or factors which represent the individual.

In a previous report[1] it was shown that the representative personal factor which is important from the standpoint of aviation requirements is the binocular parallax. It was shown by the use of an apparatus which required tests to be made at six meters that it was possible to examine the binocular parallactic ability alone and to classify men according to their skill with this factor. In that paper it was stated what seemed to constitute normal findings. In order to supplement the experiments done with the six-meter apparatus, it was suggested that an outdoor test be devised for use at 100 meters or more. In order to make the outdoor test comparable to the conventional indoor test it had to meet the following requirements; avoid shadows, reflections, and linear perspective; also the test objects must maintain approximately the same visual

[1] "A Test for the Judgment of 'Distance,'" *Trans. American Ophthal. Society*, 1919.

angle irrespective of the difference in their distances from the observer. In this way the binocular parallax could be tested and the subjects thus examined be graded according to the resultant binocular parallactic angles.

Apparatus Employed.—The apparatus finally decided upon consisted of the following parts:

(1) A set of four circular disks or semaphores painted white and each attached to a wooden dowel of small diameter. The semaphores ranged from 12 to 13.3*cm* in width. In order to render the dowels invisible they were painted brown to match the color of an outdoor field.

(2) Tripods to hold in an upright position a piece of galvanized iron piping with a bore just large enough to receive a dowel.

(3) A board screen one meter high and two meters wide to be set upright a short distance in front of the semaphores in order to cut off all view of the tripods and avoid linear perspective.

The apparatus was set up using two semaphores at a time, the nearer one being exactly 100 meters from an observer and the other, which was a trifle larger in diameter, at a greater distance away. The lateral separation of the two semaphores was one meter, *i. e.*, the angle of separation from the position of the observer was one centrad. This was the same as the angle between the rods in the six-meter test. Figure 3 represents a set-up of the apparatus with the sunlight shining upon the semaphores in line with the intended observation.

The Test Applied.—One operator and one assistant were required to test each observer. The latter was required to stand at the 100-meter station with his back to the apparatus. The operator adjusted the semaphores and gave the signal "ready" to his assistant who was standing beside the observer. The latter upon receiving the message turned around, focused his eyes upon a spot near the bottom of the board screen, and then suddenly lifted his gaze to observe the rods. In this way he was able to secure a sudden impression which was found to be so important in the six-meter test. He was also urged to keep as still as possible while making an observation.

The observer was required to state which semaphore was nearer to him, the right or the left. His judgments were taken

first at the six-meter depth difference station, then at the five-, four-, three-, two-and-one-half-, two-, one-and-one-half, and one-meter stations, or until it became apparent by the proportion of wrong judgments that he was merely guessing. With a few exceptions twenty judgments were taken at each station.

It was accepted that an observer's threshold had been passed when he failed at any station to make less than 75% of his judgments correct. Seven of the ten subjects had already been tried with the six-meter indoor apparatus so a comparison of the results of the two methods is possible.

Before proceeding with the discussion of the results obtained it may be well to consider the elements entering into the binocular parallax.

Principles Involved in the Binocular Parallax.—Figure 1 represents an observer viewing two objects, O and O′, at un-

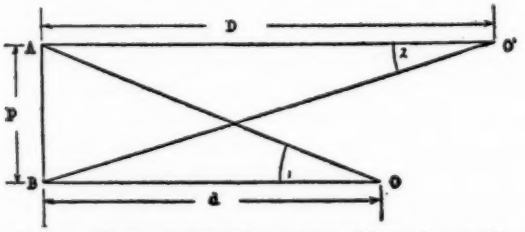


FIG. 1.—True representation of two objects O and O′ at unequal distances from the eyes A and B.
p = interpupillary distance AB.
d = distance to near object.
D = distance to far object.
D–d = difference in distance or the depth difference.
Angle 1–angle 2 = angle of the binocular parallax.

equal distances from him. If O′ be brought into a line with O and one eye B as in Figure 2, the resultant diagram will give a more graphic idea of the angles and distances involved. In this figure let p = A B, the interpupillary distance; d = the distance B O to the near object, and D = the distance B O′ to the far object. Also let angle 1 = angle A O B, angle 2 = angle A O′ B, and angle 3 = angle O A O′.

According to Figure 2, which furnishes a diagrammatic representation of the two distances D and d, the depth differ-

ence is D–d or △. Also angle 1 minus angle 2 equals angle 3, which is the binocular parallactic angle represented by the depth difference D–d.

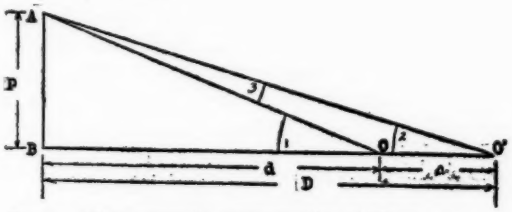


FIG. 2.—Diagrammatic representation of Fig. 1.
D–d = △ the depth difference.
Angle 1–angle 2 = angle 3, the binocular parallactic angle.

For small angles like angles 1, 2, and 3, the sine, the tangent, and the angle in radians may be considered equal with negligible error.

But the tan of angle 1 $= \frac{p}{d}$

and the tan of angle 2 $= \frac{p}{D}$

If we let r = angle 3 in radians,

then $r = \frac{p}{d} - \frac{p}{D} = p\frac{D-d}{Dd}$

Therefore, when p = 0.060 meters, d = 100 meters and D = 103 meters, by substitution

$r = .060\frac{3}{100 \times 103} = .00001747$ which represents the binocular parallactic angle in radians. In order to convert radians to degrees of arc we must multiply radians by $\frac{180}{\pi}$, and then this result by 3600 to reduce the result in degrees to seconds. Therefore, .00001747 radian = 3.60″, which happens to be the binocular parallactic angle of observer No. 2, as recorded in Table II.

On the basis of the above formula the binocular parallactic angles were computed for various interpupillary distances and

for depth differences ranging from one to twelve meters. Table I, therefore, contains all the possible parallactic angles of the ten men of this series.

Method of Eliminating the Retinal Image as a Factor.—It is stated earlier in the paper that the test objects should maintain approximately the same visual angle irrespective of the difference in their distances from the observer. This was necessary in order to rule out the size of the retinal image as a possible factor in aiding judgment. I stated "approximately the same" because it is not required that they maintain exactly the same angle in order to appear the same size.

There were four semaphores available, two of which were used at a time. One was 12*cm*, one 12.3 *cm*, one 12.6*cm*, and the other 13.3*cm* in diameter. The 12*cm* semaphore was always set at the 100 meter distance from the observer. The other semaphores were used at the more remote stations, *i. e.*, 101, 102, 103 meters, etc. As a matter of fact another 12*cm* semaphore would have sufficed because if one of that size had been placed at the 105-meter station, for example, the difference in size of the visual angles at 100 and 105 meters respectively would have been less than the minimal visual angle that is perceptible. In this instance it would have been 11.8″ which is less than the minimal visual angle threshold I found in any of ten men, a record of whom has already been reported. Among these ten I found one whose least visual angle perceptible was 13.2″ while the average of the ten was over 15.5.″ However, in order to avoid any possible error I used the larger semaphores for the longer distances and therefore reduced the difference in visual angle to 4.6″ at the most.

In Table III has been recorded the size of the visual angle subtended by a 12*cm* semaphore when it ranges from 100 to 112 meters from an observer. At a distance of 100 meters the semaphore subtends an angle of 4.125′. Table IV is a computation showing the diameter of a semaphore required to maintain a visual angle of 4.125′ at distances also ranging from 100 to 112 meters.

Some Theoretical Considerations.—In a previous report mentioned elsewhere in this paper the results of experiments with an apparatus at six meters were recorded. While examining men for the purpose of finding and establishing a normal

ILLUSTRATING DR. HOWARD'S ARTICLE ON "JUDGMENT OF DISTANCE WITH SEMAPHORES AND A SCREEN AT 100 METERS."

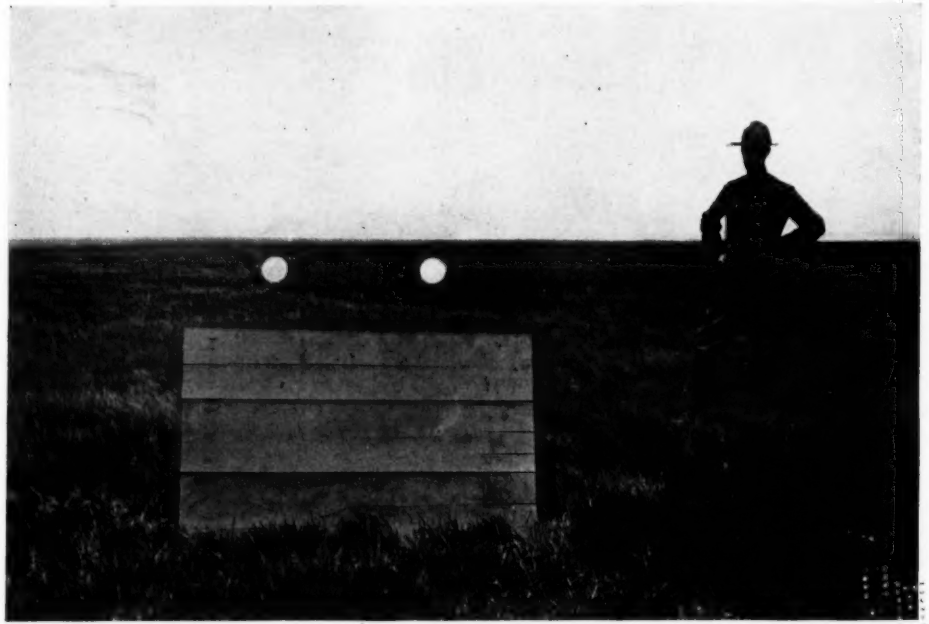


FIG. 3. A close-up view of the apparatus.

binocular parallactic angle, a number were found whose threshold angles were less than 2.0″. The smallest angle found was 1.80″, which represented an interpupillary distance of 63*mm* and a depth difference of 5*mm* when the nearer object was six meters away and the lateral separation of the two objects was one centrad.

Inasmuch as one writer, Eaton,[1] has made the statement that our "fusion sense," or the sense of depth or solidity afforded by binocular vision "cannot play any part at distances greater than 120 yards," it will be interesting to find out what the observer with a binocular parallactic angle of 1.8″ should theoretically be able to do at different distances. For instance, what would be the least depth difference perceptible when the near object is not six meters, but 100 meters away, and also one kilometer, two kilometers, etc., away.

If the parallactic angle remains constant while the distance increases, the depth difference varies approximately as the square of the distance to the first object. This, however, is true only when the depth difference is relatively small. For a distance to the first object of 100 meters there is an error of only 1*cm*. But for distances over 100 meters this approximate method of computation produces an error which increases greatly with the increase of distance. To be exact, the depth difference increases as the product of the two distances, *i. e.*, according to the formula already referred to

$r = p\frac{D-d}{Dd}$, where, if r and p are constant

$\frac{D-d}{Dd}$ must also be constant. Therefore, in the case of this observer

$\frac{D-d}{Dd} = \frac{0.005}{6.000 \times 6.005}$ (when the shorter distance is six meters).

Likewise, if the shorter distance d = 100 meters, we have

$$\frac{D-100}{100\,d} = \frac{0.005}{6.000 \times 6.005}$$

[1] "Factors in Stereoscopic Vision and in the Visual Estimation of Distance," *Brit. Jour. of Ophth.*, vol. iii., No. 2, 1919, p 63.

But for the formula $r = p\frac{D-d}{Dd}$ previously employed, we can find the value of D (and therefore also of D−d) when the other factors are known, as they are in this case.

Then

$$r\,Dd = pD - pd \text{ or}$$
$$D(p-rd) = pd \quad \text{or}$$
$$D = \frac{pd}{P-rd}$$

Therefore, when D = 100 meters, p = 0.063 meters, and r = 0.00000874 radian (1.80″), by substitution

$$D = \frac{.063 \times 100}{.063 - (.00000874 \times 100)} = 101.4$$

Therefore,

$$D - d = 101.4 - 100 = 1.4 \text{ (meters)}$$

Similarly, results may be obtained when d = 1000, 2000 meters, etc., and the ability of the observer in question may be tabulated as follows:

Interpupillary Distance.	*Binocular Parallactic Angle.*	*Distance to First Object.*	*Depth Distance Required.*
.063 meters	1.80″	6 meters	0.005 meters
.063 "	1.80″	100 "	1.4 "
.063 "	1.80″	1000 "	161.6 "
.063 "	1.80″	2000 "	768.0 "
.063 "	1.80″	3000 "	2138.0 "
.063 "	1.80″	4000 "	4989.0 "
.063 "	1.80″	5000 "	11,321.0 "
.063 "	1.80″	6000 "	29,795.0 "
.063 "	1.80″	7000 "	235,308.0 "

Again for this same individual what must be the distance of the first object when the more remote is at infinite distance. It must be that distance at which his visual axes make an angle

equal to his minimal binocular parallactic angle. Then angle 2 = 0 with its vertex at infinity. Therefore,

$$\text{angle } 1 = \text{angle } 3 = \frac{p}{d} \text{ radian}$$

Likewise, the formula $r = p\frac{D-d}{Dd}$, which is the reduced form of $r = \frac{1}{d} - \frac{1}{D}$, becomes

$r = \frac{p}{d}$ when D equals infinity. Then by substitution

$$.00000874 = \frac{.063}{d} \text{ or}$$

$$d = \frac{.063}{.00000874} = 7208 \text{ (meters)}$$

In brief, the distance at which the nearer object must theoretically be, for this individual to perceive it as nearer than one at infinite distance, is 7208 meters, *i. e.*, his depth perception theoretically is limited to this distance. Beyond that, angle 1 itself is less than his minimal binocular parallactic angle of 1.80″.

For observer No. 1, in Table II, whose minimal binocular parallactic angle is 3.37″, the binocular parallax, as a positive factor, is limited to a much shorter distance. For him the equation would read thus:

$$d = \frac{.067}{.00001634} = 4100 \text{ (meters)}$$

Discussion of Results.—Ten air service officers were examined by this outdoor apparatus. The examinations took considerable time and required great care to maintain always the operation of but the one factor, the binocular parallax. The assistant proved to be of great value in aiding the operator to secure a uniform height and illumination of the semaphores before the signal was given to the observer.

Photometric readings with a Macbeth apparatus were taken before and after several of the experiments. The average of three readings taken at the beginning of one test at 11 A.M. showed the illumination on a horizontal plane to be 5500 foot candles and on a vertical 4800. At 12 noon, when the experiment was finished, an average of three readings showed a horizontal illumination of 6300 foot candles and a vertical of 7300. At 2.30 P.M., that same day the horizontal readings showed 4200 foot candles and the vertical 9980. And at 3.30 P.M. the horizontal readings averaged 2030 and the vertical 6500 foot candles. The vertical readings were taken parallel to the line of sight when viewing the semaphores. The illumination during the other experiments compared very favorably with the two examples above, so the results of the tests are all comparable from the standpoint of good visibility.

By consulting Table II, it is noted that observer No. 1 had a depth difference threshold of 2.5 meters, which represents a binocular parallactic angle of 3.37″. His vision was $\frac{20}{10}$ — in each eye. He had perfect muscle balance and his interpupillary distance was 67*mm*, which was the widest of the ten men examined. The next two men, whose depth difference thresholds were 3 meters each, and whose binocular parallactic angles were 3.60″ and 3.73″ respectively, also had excellent visual acuity and perfect muscle balance. The other seven subjects, with one exception showed slight muscle imbalance, but very good visual acuity. Their thresholds varied from 4 to 6 meters and their minimal parallactic angles from 3.88″ to 7.53″. The average threshold for the ten was 4.15 meters and the average binocular parallactic angle was 5.19″.

Seven of the observers had previously been examined with the six-meter apparatus. A comparison of the results as recorded in Table II show a very consistent uniformity with the exception of the last case. The average minimal binocular parallactic angle obtained by the indoor test was 5.93″ as against the 5.19″ obtained by the outdoor method. Ten cases are admittedly too small a number from which to make very positive deductions or to try to establish the normal limit of the binocular parallax, but in view of the opportunity for comparison with the more convenient six-meter test, it seemed worth while to record the results, especially since they cor-

roborated quite faithfully the findings of the other test and gave support to the principles upon which the latter test was based.

It should also be of interest to learn the results of an examination made with observer No. 8 the day following his first trial. On the second day there was low visibility on account of a moderately heavy fog and a cloudy sky. His depth-difference threshold the first day was five meters, while on the second day it was eleven meters. That is, his binocular parallactic angle was 12.67″, or more than twice that of the preceding day.

CONCLUSIONS.

1. The binocular parallax, even when acting alone, is capable of great depth perceiving power.

2. The binocular parallactic angle is computed from the depth differences of objects looked at, and from one's interpupillary distance. The minimal binocular parallactic angle varies greatly with individuals and seems to have a physical basis. From data collected it seems to be dependent upon visual acuity, visual symmetry, and muscle balance to a large extent.

3. Subjects examined with the 100-meter apparatus showed binocular parallactic angles ranging from 3.37″ to 7.53″, with an average of 5.19″.

4. The findings with the outdoor test coincide very closely with those of the six-meter indoor test, but do not warrant its substitution for the latter.

5. The size of the visual angle or the retinal image has nothing to do with the binocular parallactic angle. It is wrong, therefore, to associate the visual angle with binocular discrimination of distance. The visual angle threshold is often stated as being about one minute, whereas the binocular parallactic angle threshold has been found to be as small as 1.80″.

6. Our "fusion sense" or our binocular depth perceiving ability theoretically is of value up to a distance of several thousand meters. Practically it is less, because we are limited by our visual acuity.

TABLE I.—BINOCULAR PARALLAX IN SECONDS OF ARC.

Depth differences when the shorter distance is 100 meters; *e. g.*, one meter represents the second object at 101 meters.

Inter p. d. in mm.	1	1½	2	2½	3	4	5	6	11	12
59.	1.21″	1.80″	2.39″	2.97″	3.55″	4.68″	5.80″	6.89″	12.06″	13.04″
60.	1.23″	1.83″	2.43″	3.02″	3.61″	4.76″	5.90″	7.00″	12.27″	13.26″
62.	1.27″	1.89″	2.51″	3.12″	3.73″	4.92″	6.09″	7.24″	12.67″	13.70″
64.5	1.32″	1.97″	2.61″	3.25″	3.88″	5.12″	6.34″	7.53″	13.18″	14.26″
65.5	1.34″	2.00″	2.65″	3.30″	3.94″	5.20″	6.43″	7.64″	13.39″	14.48″
67.	1.37″	2.04″	2.71″	3.37″	4.26″	5.32″	6.58″	7.82″	13.70″	14.81″

TABLE II.—JUDGMENT OF DISTANCE IN TERMS OF THE BINOCULAR PARALLACTIC ANGLE.

(One semaphore at 100 meters with screen in front; the second semaphore at 101, 102 meters, etc.)

No.	Name.	Age.	Vision.	Muscle Balance.	N. P. Accom.	N. P. Conv.	Inter P. D.	Percentage of correct judgment at the following depth distances: 1 m.	1½ m.	2 m.	2½ m.	3 m.	4 m.	5 m.	6 m.	Comparison between results of: 100 Meters Depth-Difference Threshold	Test, Binocular Parallactic Angle of	6 Meters Depth-Difference Threshold	Test Binocular Parallactic Angle of
1.	J. H.	30	R. 20/10 − L. 20/10 −	Orth.	130	80	67	48	—	60	76	80	75	100	—	2½ m.	3.37″	—	—
2.	H. T.	33	R. 20/15 L. 20/15	Orth.	150	90	60	—	—	40	60	80	80	100	100	3 m.	3.60″	10 mm.	3.44″
3.	H. L. L.	31	R. 20/10 − L. 20/10	Orth.	125	96	62	58	—	47	65	85	95	100	—	3 m.	2.73″	10 mm.	3.55″
4.	P. W. C.	46	R. 20/15 L. 20/15	Exo. ½ L. H. ½	325	100	64.5	40	60	70	—	90	80	90	100	3 m.	3.88″	10 mm.	3.69″
5.	P. D.	43	R. 20/10 L. 20/10	Exo. 2	185	55	65.5	50	55	45	—	70	90	90	100	4 m.	5.20″	—	—
6.	H. J. H.	39	R. 20/10 − L. 20/10 −	Exo. ½	145	70	59	50	60	58	—	60	64	80	100	5 m.	5.80″	15 mm.	5.06″
7.	N. B. L.	26	R. 20/15 L. 20/15	Exo. ½	130	88	62	50	—	60	50	40	65	80	100	5 m.	6.09″	20 mm.	7.08″
8.	C. R.	46	R. 20/15 L. 20/15 +	Orth.	275	55	62	60	80	40	—	60	70	90	100	5 m.	6.09″	—	—
9.	B. L. W.	56	R. 20/15 + L. 20/15 +	Eso. 4	310	75	67	50	—	70	56	25	65	90	100	5 m.	6.58″	20 mm.	7.65″
10.	F. W. H.	28	R. 20/15 L. 20/15	Exo. 1	135	67	64.5	—	—	60	—	35	55	70	95	6 m.	7.53″	30 mm.	11.03″
AVERAGE		37.8	O.U. 20/15 +	Orth.	191	77.6	63.4	50.7	63.7	55	61.4	62.5	74	89	99.4	4.15 m.	5.19″	16.4 mm.	5.93″

TABLE III.—VARIATIONS IN THE VISUAL ANGLE SUBTENDED BY A 12*cm.* SEMAPHORE AT DIFFERENT DISTANCES:

Distance in Meters.	*Angle in Meters.*
100	4.125
101	4.084
101.5	4.064
102	4.044
102.5	4.024
103	4.005
104	3.966
105	3.928
106	3.891
107	3.854
108	3.820
109	3.748
110	3.750
111	3.716
112	3.683

TABLE IV.—DIAMETER OF SEMAPHORE REQUIRED TO MAINTAIN A VISUAL ANGLE OF 4.125 MINUTES AT THE FOLLOWING DISTANCES:

Distance in Meters.	*Size of Semaphore in cm.*
100	12.00
101	12.12
101.5	12.18
102	12.24
102.5	12.30
103	12.36
104	12.48
105	12.60
106	12.72
107	12.84
108	12.96
109	13.08
110	13.20
111	13.32
112	13.44

COLOBOMA AND SO-CALLED CONGENITAL DISLOCATION OF THE LENS.[1]

By Dr. C. F. CLARK, Columbus, Ohio.

(With one figure in the text.)

IN 1894 I presented to this society the history of a case of binocular coloboma of the crystalline lens with accommodative power retained and a brief review of such cases as I could find in the literature available at that time in the library of the Surgeon General's office, and it has occurred to me that, as these cases are somewhat rare, it might be worth while to place on record the subsequent history of this patient's eyes with an interesting group of other cases which I have had opportunity to study during the past twenty-five years.

Coloboma and luxation of the lens of congenital origin, while perhaps generally regarded as clinical curiosities, have, in the group of cases I have had under observation, presented some features which have seemed to me worthy of careful study and, while the advanced students of embryology may have worked out some satisfactory theory which will account for the phenomena observed, certainly our textbooks and encyclopedias of ophthalmology, in their somewhat stereotyped presentation of the subject, have not offered an explanation which will entirely satisfy a critical observer.

It may be that some exhaustive and scientific laboratory work has been done which will supply a really satisfactory explanation of these anomalies but, if so, I have not had the good fortune to see the reports of the investigations on which

[1] Read at meeting of American Ophthalmological Society, Atlantic City, June, 1919.

such explanations are based and certainly such writers as have based their theories on the occasional instances of association of coloboma of the lens with coloboma of the iris and choroid and who speak with apparent confidence of the imperfect or delayed closure of the fœtal ocular cleft as the cause will have to revise their theories to account for the large number of cases which show no evidence whatever of coloboma of either the iris or choroid. The ingenious theories of some eminent writers of many years ago have been quoted in the textbooks from year to year as authoritative without being subjected to critical analysis, but I fail to see how some of the cases I have observed can be satisfactorily accounted for or made to fall in with these theories.

Many of us lack the deep and intimate knowledge of the embryology of the eye necessary to enable us to supply an adequate theory which will account for a coloboma occurring in the upper or lateral border of the lens, or for the existence of a pronounced coloboma of the lens with no defect in either the iris or choroid, but it does not require a deep knowledge of embryology to enable us to detect the inadequacy of the text-book theory which groups these cases together and is satisfied with a glib reference to the imperfect closure of the fœtal ocular cleft as an explanation of such phenomena.

It is not always agreeable for learned writers to acknowledge that they do not know but when one finds a manifestly inadequate theory quoted by one standard authority after another he is tempted to say that an explanation which does not explain is often worse than no explanation at all.

The case described by me in 1894 was very similar so far as the defect in the lens is concerned to one described by Cissel in 1890. My patient Edward S. of Marysville, Ohio, ten years of age, had marked asthenopic symptoms and a trembling iris with a marked coloboma at the lower border of each lens. I had his case under occasional observation from 1888 to the time of his death in 1912 and while there was some slight evidence of premature presbyopia at the time of his death at the age of thirty-four, his lenses had remained quite clear and his corrected vision had improved from $\frac{4}{18}$ to $\frac{5}{7.5}-$ in each eye.

He attended school and reported to me from time to time on account of the occasional recurrence of asthenopic symp-

toms. These were relieved by a careful correction making allowance for the changes in his refraction which seemed to vary from year to year and to be due in the main to a gradual change in his lenticular astigmatism.[1]

In my report of this case of coloboma in Edward S. made in 1894, I made a rather full record of the refraction, both corneal and lenticular, and in my studies of the case after the lapse of many years it was interesting to note that while the myopia remained about the same, namely, R. −7.5 sph.; L. −5.5 sph.; the astigmatism increased from R. −1. cyl. axis 10°, L. −2.75 cyl. axis 170° in 1894 (at which date the corneal and total astigmatism were practically the same) to right, −3.50 cyl. axis 180° and left −5.5 cyl. axis 180° in 1912. An increase of the total astigmatism in the right of 2.5 D. and in the left of 2.75 D. is manifestly due to a change in the form of the lens. While in the case of congenital dislocation in Kenneth A. referred to above, there was, apparently owing to release from the pressure of the suspensory ligament, a considerable degree of myopia and a modification of the astigmatism apparently due to tilting of the lens.

Both of these cases were in boys who were under observation for many years, whose lenses remained clear and who had good vision when their varying refraction was properly corrected. In one there was a marked coloboma in the lower segment of the lens in each eye while in the other the lenses were dislocated upward and slightly outward. The changes actually observed in the refraction of these cases were apparently quite consistent with what we should naturally anticipate if we observe with care the phenomena of coloboma and congenital dislocation, and the point of great interest to me was that in spite of their deformities the lenses remained clear under the observation which was maintained for a series of years.

In the case of coloboma, the lens remained in the normal

[1] I wish to call special attention to this point as I have observed it in a number of the cases of coloboma which I shall report and to contrast it with astigmatism occurring in a case of congenital dislocation in Kenneth A. in which latter case it seemed to be due, at least in part, to the inclination or tilting of the lens which, released from the pressure of the suspensory ligament, also caused a marked degree of myopia remaining about the same for many years.

position but slowly changed its form, while in the case of dislocation it changed its position as well as its form, and in the latter case I would call attention to the fact that in congenital subluxation, so long as the anterior surface of the vitreous body maintains its normal curvature, the movement of the lens is apt to be such that its posterior surface slides on the wall of the lenticular fossa and the lens consequently tilts forward at such an angle as to produce a degree of regular astigmatism. While there are great variations in the size of the colobomata and the degree of dislocation in the cases I have had the opportunity to study the two cases referred to above may be taken as in a degree typical and I will only refer briefly to a few of the others which present some interesting points.

Out of a total of eleven cases of this class occurring in my practice during a period of thirty-five years, eight had coloboma and four had congenital dislocation, in one case both coloboma and dislocation were found in the same patient, and, while the textbooks and encyclopedias almost invariably speak of coloboma of the lens as associated with and dependent upon the same causes as coloboma of the iris and choroid, in *not one of my eleven cases*, and a considerable number of instances in which coloboma of the iris and choroid were observed, could I find the two conditions associated. I am again calling attention to this point as I wish to emphasize the fact that an ingenious theory concerning a somewhat obscure histological subject, if proclaimed by some high authority, will go unchallenged for years though a careful analysis of the facts may afford no warrant for its acceptance.

Of the eleven cases referred to above, it is interesting to note that seven occurred in the descendants, in two generations, of one man and that there is room for a strong suspicion that both he and his father had similar trouble. The record of this interesting family will be found on the accompanying chart in which an effort has been made to present the relationship of the various members of the group in as condensed a form as possible.

A number of these patients have been under observation for periods varying from six to twenty years and, as in most instances the lenses have remained clear and in other respects the eyes have been normal, they have afforded an opportunity

to study the variations in the refraction of an eye which may be supposed to accompany certain changes in the shape of the lens, apparently resulting from, first, the absence or relaxation of a sector of the suspensory ligament as in coloboma; second (in luxation), the increased rotundity of the lens increasing its refractive power, and, third, the astigmatism resulting from the inclination of the axis of the lens as, in its luxation, it follows the curve of the lenticular fossa.

To follow and accurately account for all of the optical phenomena resulting from slight changes in the lens or its position in the lenticular fossa would demand a degree of skill to which I lay no claim, but a simple record of some of these cases will, I think, be of interest.

Even in the cases of small colobomata or slight subluxation asthenopic symptoms were not uncommon and a revision of the refraction from time to time gave marked relief. The degree of accommodative power retained in spite of a large coloboma and marked trembling of the iris was quite remarkable but when the refraction was accurately corrected, it was still more remarkable to see how much comfort the patient would obtain and one would be surprised to see *how slowly* variations in the refraction of the lens took place. The best demonstration of these changes in coloboma of the lens was found in the case of Edward S. mentioned above, which case was first reported to this society in 1894.

In the H. family illustrated in the chart, whose members demonstrate so fully the various possibilities of coloboma and dislocation, there are shown among the younger generation two cases: Miss Jewell H. (5 A) and Miss Bertha A. (8 A), who, in spite of their well-marked colobomata have good accommodative power, astigmatism which has remained practically the same since they have been under observation, and, when corrected, practically normal vision. Miss Jewell H. (5 A) has been under observation for six years and her cousin, Miss Bertha A. (8 A) for seven years. A third member of this group, Miss Millie H. (5 B) has been under observation for some sixteen years, but as she was very young when first seen the refraction was not accurately worked out at that time, and there seemed to be a degree of amblyopia, the vision with a correcting lens being only $\frac{6}{15}$ right and $\frac{6}{20}$ left but, after wearing an

approximate correction for fourteen years, she was able in 1917 to obtain almost normal vision in each eye:

R. − 2. sph. ⊂ − 2. cyl. axis 180° = $\frac{4}{4}$ −
L. − 2.25 sph. ⊂ − 3.5 cyl. axis 165° = $\frac{4}{4}$ −

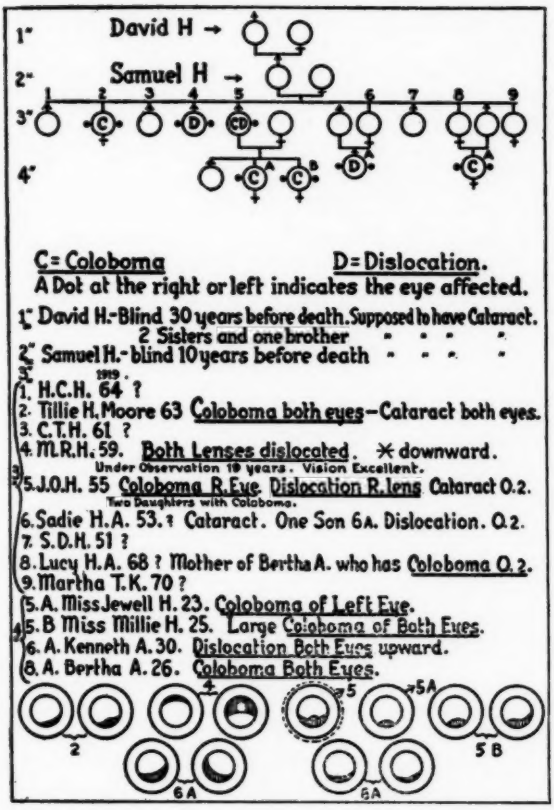
and this remained practically the same when she was last seen in March, 1919. These three are still young people and, if I may judge by my experience with other cases, I would be inclined to look forward to somewhat marked changes in the astigmatism of their lenses when they are a little older.

In a few instances, generally rather late in life, opacity has developed in the colobomatous lens, but in most of my cases, the truncated border of the lens has been apparently clear and free from evidence of any disease or disarrangement of the lens cells resulting in opacity. While in congenital dislocation of the lens it is not uncommon, as in the case of Kenneth A. (6 A in the chart) to find on the lens border the remains of the stretched or ruptured fibers of the suspensory ligament, I can now recall no case of coloboma in which such evidences of a suspensory ligament were to be found and in the larger colobomata the truncated border while rounded and thick was smooth and clear. I fail to understand how, if our commonly accepted theories of the mechanism of accommodation are correct, we can have the suspensory ligament absent over as much as one third of the periphery of the lens and still have only a moderate degree of astigmatism and good accommodative power. This would seem to cast some doubt upon the theory of so-called dynamic astigmatism due to a contraction of a sector of the ciliary muscle.

In only two of my cases (Tillie M. (2) and Millie H. (5 B) in the chart) were the colobomata large, and in Tillie M., forty-seven years of age, cataract was so far advanced when she was first seen that a study of her accommodative power was of course out of the question.

It is not difficult to understand how the normal tension on the suspensory ligament can maintain the flattening of the elastic lens of a young person and allow of a fair degree of accommodation in the relaxation accompanying contraction of the ciliary muscle even in the presence of a small coloboma,

but it would give me great pleasure to hear from some of the members of this Society who have given attention to the problems involved in the physiology of refraction and accommoda-


1st David H →
2nd Samuel H →
3rd
4th
C = Coloboma
D = Dislocation.
A Dot at the right or left indicates the eye affected.
1st David H.-Blind 30 years before death. Supposed to have Cataract.
2 Sisters and one brother " " "
2nd Samuel H.-blind 10 years before death " " "
3rd
1919.
1. H.C.H. 64 ?
2. Tillie H. Moore 63 Coloboma both eyes—Cataract both eyes.
3. C.T.H. 61 ?
4. M.R.H. 59. Both Lenses dislocated. ✳ downward.
Under Observation 19 years. Vision Excellent.
5. J.O.H. 55 Coloboma R. Eye. Dislocation R. lens Cataract O.2.
Two Daughters with Coloboma.
6. Sadie H.A. 53. ? Cataract. One Son 6A. Dislocation. O.2.
7. S.D.H. 51 ?
8. Lucy H.A. 68 ? Mother of Bertha A. who has Coloboma O.2.
9. Martha T.K. 70 ?
5. A. Miss Jewell H. 23. Coloboma of Left Eye.
5. B Miss Millie H. 25. Large Coloboma of Both Eyes.
6. A. Kenneth A. 30. Dislocation Both Eyes upward.
6. A. Bertha A. 26. Coloboma Both Eyes.
4
5
5A
2
5 B
6A
6A

tion as to how, when one third of the lens periphery is no longer connected with the ciliary muscle, we can still have good accommodative power.

In one case in this family, J. O. H., a man of 55 (No. 5 in the chart) we have a small semicircular coloboma of the lower border of the lens associated with dislocation upward and some-

what advanced cataract. This man is the father of two of the girls mentioned above, Miss Jewell H. and Miss Millie H.

The surprising conditions that may develop in the life history of a case of congenital dislocation of the lens are well illustrated in Mr. M. R. H. (No. 4 on the chart) whose case was described in a paper on "Dislocation of the Lens" read before the Section of Ophthalmology of the Ohio State Medical Association. As he is a member of this family group and his case is a very unusual one, I will briefly present some of the points of interest which bear on the subject under discussion.

On consulting me in July, 1899, this man had partial dislocation of both lenses downward and, while he stated that he had always been "nearsighted" he gave an account of a sudden and very marked impairment of vision following violent exertion. This sudden impairment had occurred in the right eye some four years, and in the left some twenty-four hours, before he consulted me. In the right eye the stretched superior portion of the suspensory ligament could be plainly seen.

Taking into consideration the family history, the account he gave me of the accidents, and the appearance of the eyes, I was of the opinion that I was dealing with a man who, like his nephew, Kenneth A. (6 A in the chart), whom I saw two years later, had a congenital dislocation, probably upward, which, in his case by a sudden jar had been converted into a dislocation downward.

The glasses he had been wearing, R. + 2.25 sph.; L. + 2. sph. ⊃ − 8. cyl. axis 180° were evidently given to correct vision through that portion of the lens which remained in the pupillary area, but much better vision was obtained through the aphakic portion of the pupil. This, however, required the use of a strong lens, + 15. sph. right and + 16. sph. left in addition to the correction of his corneal astigmatism, showing that the eyes prior to the dislocation of the lenses were normally hyperopic, but a portion of this hyperopia was neutralized by the increased refraction of the more rotund lens released by the luxation from the restraint of the suspensory ligament. It is also probable that the high degree of lenticular astigmatism was at least in part due to the tilting of the lens.

The recently luxated left lens in this patient was still movable and by placing him alternately on his back or having him

lean forward with his face down, I could obtain varying states of refraction as the lens was nearer to or farther from the retina, and again on carefully placing his head in the vertical position he could, with proper correction, see well through the crystalline lens but, on shaking his head, the lens would fall low enough to enable him to obtain excellent vision over its upper edge.

Both lenses finally settled to a point 1 or *2mm* below the horizontal meridian and have remained in that position for many years apparently causing no symptoms of irritation and allowing the patient with proper lenses, R. + 18.5 sph. and the left + 18. sph. ⊃+ 1. cyl. axis 15° to obtain almost normal vision in each eye. This was in 1903: R. $\frac{6}{6}$ − and L. $\frac{6}{6}$ − and in 1919 it was, with the same lenses, R. $\frac{6}{6}$ − and L. $\frac{5}{7.5}$ −

There is some prominence and slight fading of the iris in the inferior quadrant at the point where the lens presses it forward and the pupils are only about *2mm* in diameter in ordinary light and reduced to *1½mm* in strong light and almost straight on their lower borders. A remarkable feature of this case is that with the strong lenses which he has worn constantly for sixteen years he has had practically normal vision for distance with either eye or both eyes in combination, and at the same time reads fine print with ease.

Whether this "accommodation" is obtained by virtue of the stenopæic pupil alone, or by this in combination with the inclination of the strong correcting lens (as suggested by Dr. Risley), I leave for your decision but, on the occasion of his last visit on April 24, 1919, he had with the right + 20. $A = \frac{.18 - .51}{.75,} = .33$ and with the left + 20. sph. ⊃ + 1. cyl. axis 15°, $A = \frac{.21 - .50}{75} = .29$

The literature of ophthalmology contains many various and curious instances of coloboma and congenital dislocation of the lens, but the phase of the subject which has interested me most deeply is the side light which some of these cases throw on the study of refraction and accommodation. What is spoken of by some writers as dynamic, lenticular astigmatism, the form of astigmatism which changes with the act of accommodation, might naturally be supposed to be modified by a condition of

the eye in which a relatively large sector of the lens periphery is left entirely without connection with the ciliary muscle, but we are surprised to find that in some of the younger cases, not only is there very little lenticular astigmatism but that, with the refraction corrected, both vision and accommodation are practically normal.

The successful study of this subject requires that we should have our cases under observation from time to time for a series of years, preferably from childhood to forty or fifty years of age. Only a few of my cases approximate these conditions but I hope that some one may be able to follow the future history of certain of these eyes and we may thus learn from actual observation rather than by theorizing what the ultimate effect is when, without other complication, a clear lens goes through its life with a considerable portion of its periphery unattached to the ciliary muscle.

I venture the opinion, subject to correction and revision, that a careful study of the cases of Edward S. (whose record is continued in the early part of this paper from the account given in my first report in the transactions for 1894), and those cases of coloboma in the fourth generation of the H. family as shown on the accompanying chart will warrant the following conclusion: In youth the elasticity of the lens is such that, in spite of the absence of the zonular fibers over a relatively large sector of the lens, accommodation for that portion of the lens opposite the normal pupil may be satisfactorily accomplished without a marked degree of lenticular astigmatism being apparent, but as the lens gradually becomes rigid with age (and this age is a relative term) an increasing degree of astigmatism of the lens is developed.

A CASE OF BILATERAL GLIOMA OF THE RETINA APPARENTLY ARRESTED IN THE NON-ENUCLEATED EYE BY RADIUM TREATMENT.[1]

By MARK J. SCHOENBERG, M.D., New York.

AXENFELD reported in the *Klinische Monatsblaetter f. Augenheilkunde* of 1914 (vol. lii.) and of 1915 (vol. liv.) on the case of an eight months' old baby with glioma of the retina of both eyes. The right eye was enucleated, and the left eye, containing several foci, was treated with mesotorium and X-rays. The results obtained by Axenfeld were so encouraging that I applied the same treatment in my patient herewith reported.

Alice W., 5 years of age, came under my observation on March 15, 1916, when two years old, with the following history: Mother had noticed that when the child was only one month old, "the shine of the pupil of the left eye was different than it ought to be." No attention was paid to this condition until a few days before calling on me. Examination revealed a typical clinical appearance of a glioma of the retina of the left eye. The other eye also showed a mass adjoining the optic nerve and extending from it downwards and nasally. Personal and family history negative. No history of infection or trauma in child or mother during pregnancy or after birth.

On March 17, 1916, the left eye was enucleated and while under the influence of the anæsthetic the right eye was carefully looked into. It was then found a sharply circumscribed, grayish white tumor, limited above and below by branches of the retinal artery, occupying an area a little larger than a

[1] Case presented before Section on Ophthalmology, New York Academy of Medicine, May, 1919.

quadrant of the eyeground, extending from the margin of the disk nasally and below, towards the periphery, but not reaching the latter. This area was surrounded on all sides by patches of choroidal atrophy with pigmented borders. In its central portion were two small spots of gliomatous degeneration. Above, way over to the periphery, was another small grayish mass occupying an area of about 4–6 disk diameters.

Prof. J. Ewing (Dept. of Pathology, Cornell University Medical College) had the kindness to examine the enucleated eye and reported as follows: "Typical glioma of the retina. The tumor is composed of very small cells, consisting chiefly of nuclei, sometimes arranged in small rosettes and quite characteristic of glioma retinæ." A few days after the enucleation the child was referred to the General Memorial Hospital of New York where it received a course of radium and Roentgen rays treatments under the able direction of Dr. H. H. Janeway. On April 10, 1916, first radium treatment: radium emanation 36 millicuries with lead filter, applied to the right temple for four hours. On Sept. 22, 1916, second treatment: 58 millicuries, filtered through a 4 sq. *cm* lead plaque, held over the eye at a distance of *1cm* for eight hours. On June 7, 1918, a third radium treatment was given: 209 millicuries over the right side of the orbit, kept for fourteen and one half hours, filtered through plaques of lead *2mm* and silver *½mm* thick.

Repeated fundus examinations were made during the past three years not only by the writer but also by late Dr. O. Schirmer, Drs. C. W. Cutler, A. Knapp, and J. Weeks.

On March, 1917, the condition was found as follows: Optic disk distinctly visible, sharply outlined; temporal half somewhat pale. Vessels normal; nasal and lower branches appear slightly enlarged. There is a large area, whitish of color, occupying the nasal lower quadrant, reaching with one angle nearly up to the margin of the optic disk and stretching towards the periphery at a distance of about 20 disk diameters. The color of this area is slightly yellowish gray. There is a number of sharply outlined, lighter yellow spots present, especially in the lower nasal angle. The whole mass is distinctly prominent but not very considerable. The outlines are not sharp, rather cloudy. The whole mass is surrounded nearly entirely by old choroiditic spots, consisting of white, sharply outlined patches, surrounded by pigment or containing pigment. When the child looks straight upwards one sees rather near the periphery another large yellowish gray spot of about 10 D. D. The vessels going to the spot are considerably dilated and tortuous. The appearance of the spot in color and outline is the same as in the

upper mass and are still more marked, sharper outlined, and larger. No choroiditic changes around this mass. The age of the patient, the color of the tumors, and the glistening spots of their surface speak for glioma.

May 22, 1918. Patient feels and looks well. Names small pictures at a distance of 6–8 feet. The growth is about 6 D. high. It shows three glistening whitish spots of retinal degeneration and a portion of an arterial branch running horizontally across it for a distance of about 3–4 D. D. The mass gradually slopes down towards the area where the choroidal patches are. The upper growth shows no choroidal changes surrounding it.

Sept. 30, 1918. Patient weighs forty pounds, feels and looks well. Upper growth possibly a little larger. Posterior portion of lens, very near the pole, shows a pellicle like opacification, surrounded by dust-like fine opacities, scattered in the posterior cortical layers.

Nov. 11, 1918. Gaining weight (47 pounds) V. $\frac{20}{100}$ plus. The lower growth seems lobulated, white, smaller in extent but apparently elevated, it partly seems to cover the lower and inner $\frac{1}{3}$ of the disk. The mass looks now more like an exudate, whitish, silvery prominent, woolly. Tension normal.

Dec. 5, 1918. A circumscribed circular opacity at posterior pole of the lens surrounded by dusty opacities. Vitreous clear. An organized vitreous opacity covering over the retinal mass. The latter consists of an irregular, lobulated area, apparently very slightly raised, of extreme white color, over which blood-vessels run. Some of these white masses have glistening white areas of degenerated portions of retina. The mass is surrounded by patches of choroidal atrophy. At the extreme upper and nasal periphery there is a similar process, very much smaller in size.

At the last examination of the patient, made in June, 1919, the condition was the same. The child looks and feels well. The opacities in the lens appear slightly more dense. The fundus appearance did not change. The impression is gained, that all that was left of the glioma is a degenerated necrosed mass. As to the upper focus, the appearance is about the same, but being situated at the extreme periphery, it cannot be examined any length of time (the child does not keep quiet long enough).

So far, there are two other cases of glioma of the retina reported in literature, which have been treated successfully by X-ray and radium. One is Hilgartner's case (after Pusey and Caldwell, *Therapeutics of Roentgen Rays*, p. 609), a child

3½ years old with a glioma, filling up the right eyeball and a small growth in the left eye. After eighty-four exposures to X-rays the right eye shrunk to ⅔ of its size and the growth in the left eye resorbed. There is no microscopic examination of the growth and, of course, this weakens the evidence as to the accuracy of the diagnosis.

The Axenfeld case concerns a baby, eight months old, which came under his observation in 1914. One eye was filled by a gliomatous mass; in the other eye there was one small tumor above at the beginning, but later on two more small foci appeared. The eye with the large tumor was enucleated and the microscopic examination revealed the presence of a typical glioma. A course of mesotorium and X-ray applications was given to the other eye over a period of one year and the report at the end of the course is most encouraging. "The optic disk is normal. The tumor below the macula has almost completely disappeared. All that can be seen is a small spot corresponding to the central portion of the area where the tumor was situated. The smallest tumor shows two lobes connected by a narrow bridge. Its appearance has changed considerably. Its periphery shows grayish green almost flat patches. The entire tumor is very much less prominent. No pigment spots to be seen anywhere near this tumor."

Axenfeld thinks that the X-ray and mesotorium have had an elective action upon the new growth cells but that future experience will show whether the brain tissue is at the same time influenced in any way by these rays. He advises to watch the mentality of the patients. The lens remained clear.

My patient presents a number of features worth pointing out: (1) The length of time under observation (over three years). (2) The microscopic evidence as to the correctness of diagnosis. (3) The chorioretinal patches surrounding the growth. (4) The lenticular changes during the treatment. (5) The good vision, and general condition and the absence of increase of tension three years after the glioma had been discovered and treated. (6) The apparent arrest, recession, and degeneration of the gliomatous masses.

The report on the final outcome of this case will be made in due time.

ILLUSTRATING DR. LLOYD'S ARTICLE ON "PHANTOM INTRAOCULAR TUMOR. MULTILOCULAR CYST OF IRIS AND CILIARY BODY."

PHANTOM INTRAOCULAR TUMOR. MULTILOCULAR CYST OF IRIS AND CILIARY BODY.

By RALPH I. LLOYD, M.D., F. A. C. S., Brooklyn, N. Y.

(With one illustration on Text-Plate XV.)

M. F., came to the clinic of the late Dr. A. B. Norton, complaining of poor vision in the left eye. He was a tailor, aged 51 years, and says the failure of vision dates back only three months. The vision of the right is $\frac{20}{30}$ without correction but he can only count fingers at two feet with the left eye.

Correcting glasses were tried without benefit to the poorer eye. Examination of this eye revealed a cortical cataract located near to the posterior pole and not large but dense. There was very little general lenticular haze surrounding the opacity and no spicules running in from the periphery.

The interior of the eye could be thoroughly examined with the pupil dilated and there were a few pigment flecks visible on the anterior surface of the lens. The nasal portion of the iris was pushed forward and by looking down and in through the pupil, one could see a light colored mass located between the iris and the lens and a narrow band leading backward to a dark colored mass which was posterior to the lens and evidently on the inner surface of the ciliary body. When the pupil was dilated, the mass was more easily seen and it then appeared as if made of several smaller masses. Transillumination was perfect and we were unable to find any interference with light transmission. To the fingers, tension seemed normal or less and the readings taken with the Schiotz instrument were 10–12*mm* for the right and 12–13 *mm* for the left. The McLean instrument gave us 18–19*mm* for the right and 25*mm* for the left. The pupil was dilated and the tension taken with the Schiotz instrument and we find the tension under mydriasis to be 16*mm* as compared with 12–13*mm* without. The Wassermann test was reported negative.

Because of excellent light transmission, lobulated appearance, unchanged tension and color, suggested a cystic tumor of the iris or the ciliary body because the mass might easily project from the ciliary body and reach a place between iris and lens and give the impression that it originated in the iris.

The pigment flecks on the anterior lens surface with a cataract of a type which suggested a cause within the eye itself, made us think of uveal disease but there were no floating opacities present. Literature contains ample precedent for removal of the eye in suspicious cases but it seemed best to make an iridectomy and carefully examine the section removed. Dr. Norton approved of this plan and the iridectomy was done without incident other than profuse hemorrhage which was anticipated. The iris repositor was used without being able to see whether the iris was returned to proper position or not. The blood clotted at once, quite a little escaped from the incision, but there was nothing further except a puckering of the lens capsule, half-way between center of lens and inner border, where the blood clot organized in a small mass.

After the chamber cleared, nothing of the former mass was to be seen nor did the section removed from the iris appear abnormal. Also, the band spoken of and the dark colored mass behind it in the vitreous chamber have both disappeared. On the lens surface, close to the inner margin is a light colored smear.

For this state of affairs, we were prepared because of an article by Dr. A. Knapp, page 609, vol. xl., ARCHIVES OF OPHTHALMOLOGY. Here is described a very similar condition but the mass was dark in color. The patient's eye was also pushed far forward by what was later found to be an aneurysm of the ophthalmic artery. The section of iris was sent to Dr. DeNyse of the Carson C. Peck Hospital Laboratory who says "the epithelial layer of the iris posterior surface is detached and this may or may not be pathological. The layer is very much reduplicated, contains pockets, and is in excess of the amount necessary to properly cover the surface allotted. Without doubt, this layer has been ballooned by fluid." A microphotograph of the section is offered. The angulation of the section is due to the folding of the iris in the grasp of the iris forceps.

The sections are cut at right angles to the radius of the iris, crossing the mass of the tumor and the pupillary margin does

not appear. No effort was made to get every bit of the tumor because a small iridectomy was preferred, if the mass was innocent, while the eye would have been removed at once had the microscopist reported malignancy present. The case seems a rather rare one, but the usefulness of careful reports in making diagnosis in doubtful cases or assisting in shaping the course of treatment is prominent because I very much doubt whether we would have done as we did had not the case report in the ARCHIVES been in our mind.

A CONTRIBUTION TO THE STUDY OF DARK-ADAPTATION.[1]

By PERCY W. COBB, Captain, M.C., Medical Research Laboratory, Hazelhurst Field, Mineola, Long Island, N. Y.

(With four figures in the text and one figure on Text-Plate XVI.)

VISION under ordinary conditions and vision under extremely low intensity of light present quite different sets of phenomena. The latter phase of vision has heretofore been of interest from the diagnostic standpoint, and has been investigated and discussed as a problem in visual physiology.

This problem has related itself mainly to the demonstrable anatomic changes corresponding with exposure of the eyes to light or darkness, notably the presence or absence in the rods of the light-fugitive visual purple, the variations in the shape of the pigment cells and in the distribution of their pigment, and the possible shift in the position of the cones. Of these, the phenomena connected with the visual purple have been correlated with certain experimental changes in the vision of light and color characteristically related to the change between high and low light-levels, and have given rise to the theory of dual function. Stated briefly, this theory assumes that sensations of color are due entirely to changes resulting from the incidence of light on the visual cones. Colorless light-sensation mediated by the cones is also admitted; but sensitiveness to color is denied the rods which are held to give only light impressions undifferentiated in color, and to be capable of extreme enhancement in sensitiveness after a period of removal from strong

[1] Presented by invitation before the American Ophthalmological Society, June, 1919.

ILLUSTRATING DR. COBB'S ARTICLE ON "A CONTRIBUTION TO THE STUDY OF DARK-ADAPTATION."

FIG. 1. General review of the experimental set-up. The test pattern appears on the square white surface at the end of the adaptometer. Above this is the fixation mark with dry cell attached. The white screen used for the purpose of "blinding" the subject is below in the foreground.

light. The changes in function that take place in normal vision in transition from high (daylight) to low (twilight or night) intensities of light can be enumerated briefly:

1. Color, as a visual quality, disappears. Objects are seen as lighter or darker, but not as of different colors.

2. Concomitantly a shift of sensitiveness, with relation to the position in the spectrum, takes place. The bright spectrum presents all the rainbow colors, and has its brightest part in the yellow. The dim spectrum is devoid of color. At its red end it has ceased even to be luminous, and its brightest point is found to be of shorter wave length (*i. e.*, farther towards what was the green) than the brightest part of the daylight spectrum.

3. An enormous enhancement of the absolute sensitiveness to light takes place. This is progressive and when measured is found to be rapid at first, then slower, and is found to become stationary in an hour's time or less.

It is the increasing sensitiveness of the darkened eyes, or dark-adaptation, which concerns us here. This phenomenon has long interested the student of visual physiology and has been investigated as a possible aid in the diagnosis of certain conditions involving the retina. Further than this it has not had technical importance.

In times of peace it is a simpler expedient to provide light than to try to see in the dark. The way of warfare is different, and to choose for the enemy unfavorable natural conditions which one has himself learned to meet is a part of good strategy. To orient himself with reference to terrestrial objects the aviator cannot depend upon hearing. The roar of his motor would make this impossible, even though otherwise he is not too far away. The experiment of feeling his way is unintentional because it is usually fatal. Both with respect to objects on the earth and to other airplanes the aviator must rely upon his vision alone. When night flying became a part of military strategy the classification of aviators on the basis of night vision became a problem worthy of study.

In attempting to find the lowest limit of light sensitiveness we at once encounter the fact that the light threshold is, apart from irregular variations, a variable quantity. The subject, taken into a dark room, at first requires an amount of light which is many times that necessary a few minutes later.

Exact researches have shown that the factor may easily be several thousand. In coming from bright daylight into the dark room the threshold has been shown in normal individuals to be 1500 to 8000 times that obtained an hour later, the subjects in the meantime remaining in the dark.

It has also been shown that the rate at which the threshold amount of light decreases is not always the same for the same individual, but depends upon the duration and intensity of the light to which the subject's eyes have been exposed during a (perhaps indefinite) period just prior to the experiment. The present work proposed investigating the quantitative relations regarding this last point, as well as determining the ultimate light-sensitivity of individuals and their characteristic mode and rate of recovery from the partial and temporary blinding due to light. The aim was to arrive at some idea of individual variations in these respects as preliminary to the devising of a practical and valid method of testing.

The detailed procedure used in conducting the experimental work at present under consideration will appear in another place. An outline of the essential facts will be given here.

The subject coming into the experimental room is seated facing the adaptometer (Fig. 1). On a level with his eyes, and 52*cm* away is a small red light dimmed as far as is consistent with certain fixation upon it in the dark. The test pattern is in the same vertical plane as the fixation point, its center 12*cm* directly below the latter. The test pattern is best described as a square, 7.5*cm* on each side, from which the middle third is removed, leaving two parallel rectangles, 7.5 x 2.5*cm*, with a dark space 2.5*cm* wide separating them. The center of the pattern is 13° below the point of fixation, and its extreme limits subtend about 8° horizontally and vertically in the visual field. This pattern is projected upon a sheet of milk glass, from the side away from the observer, by a device which is essentially a small stereopticon. The latter is enclosed in a light tight box, the milk glass being a window set in one end. The amount of light projected, and hence the brightness of the test pattern, was controlled and measured by means of a gelatine smoke wedge. The form of the pattern is determined by openings in a thin slip of brass, which represents the "slide" in the stereopticon. Two pairs of openings were used, one

with the two rectangles in the vertical position, the other in the horizontal, and the change was made by a horizontal shift of the slide.

(1) As soon as possible after the subject entered the room the latter was darkened and his threshold was taken. This was repeated with approximately five-minute intervals of rest. In twenty or thirty minutes it was found that his threshold had reached a limit, and had become constant to within what could be called the margin of experimental error.

(2) When this was assured by the results, the first part of the experiment proper began, involving a measured amount of "blinding." A white screen was set up obliquely before the subject and the center light of the room was turned on. The screen subtended 67° vertically and 70° horizontally in his visual field, and its brightness averaged 13 candles per square meter. The subject was instructed to look at the central part of the screen, without especial effort to fixate. At the end of five minutes the light was turned off and the screen removed. In the meantime the test pattern had been set at a certain rather high level of brightness, and the time elapsing between the darkening of the room and the first visibility of the pattern was taken. After that the threshold was taken as before but with somewhat shorter intervals, until it had reached its former final value.

(3) When this had taken place the white screen was replaced and the procedure repeated as under (2), with fifteen seconds' exposure to the screen instead of five minutes.

This procedure was planned with the idea that the first portion would serve two purposes, to give a value for the absolute threshold of the subject and at the same time to bring him to a standard and reproducible state (that of complete dark-adaptation) before subjecting him to a standard amount of blinding. Obviously this latter would mean nothing unless the effects of previous light exposures had come to an end, and there seemed no way of making certain of this but to follow the subject's threshold to a constant value. There seems to be some evidence that even this, as done here, is not adequate. In two cases, the experimental order was varied, parts 2 and 3 of the experiment being transposed in order. Comparison of these results with the bulk of the results seemed to indicate

that whichever stage (2 or 3) of the experiment was conducted last was subject to a residual effect from the blinding of the foregoing part, in spite of the fact that the subject had, in the meantime, come back to his first ultimate threshold. This was evidenced by a somewhat more rapid recovery in these two cases than was to be expected in part 3 when this took second place in order, and by a slower recovery in part 2 when this took third place.

A study of the results yielded a set of numerical values which are summarized in Table I. From this it will be seen that the individual variations are quite large, on every point. For example, in different individuals the absolute threshold was found as high as 9.95 and as low as 1.34 millionths of one candle

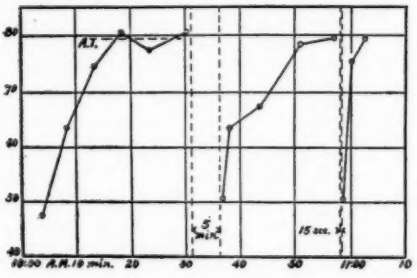


FIG. 2

per square meter. The mean value for all subjects was 4.97 with a mean deviation of 2.18 millionths or 44 per cent. of the mean.

A specimen of the course of adaptation is shown graphically in Fig. 2, the three curves being the graphs of parts 1, 2, and 3 of the experiment, as described, and the intervals of measured blinding being indicated by the vertical dotted lines. The ordinates of the plot indicate the position of the wedge, by which the intensity of the light was cut down. The relation between the shift of the wedge and the brightness of the test-pattern is a logarithmic one, such that the brightness is reduced by a constant fraction for equal linear shifts of the wedge. With the wedge at 0.0*mm* the brightness is 0.0272 candles per square meter, which is in effect divided by 2.79 for each 10*mm* shift of the wedge. The relation between these readings in

millimeters, and the actual brightness of the test pattern, in decimals of one candle per square meter, is shown by the comparative scale of ordinates in Fig. 5. The decimal scale alone appears in Fig. 4, and in these two figures the horizontal lines indicate the intervals of a tenfold change in brightness.

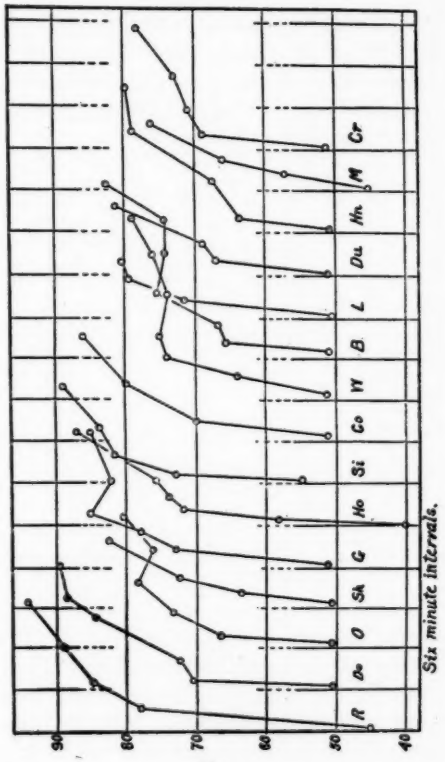


FIG. 3

Returning to Fig. 2, the absolute threshold is indicated at the height of the first curve by a horizontal dotted line. It is placed at the mean of the three points indicated. The relation between amount of blinding and the rate and mode of recovery appears from consideration of the next two curves. For a blinding period of five minutes the curves show characteristic differ-

ences as exhibited in Fig. 3; where the results for all fifteen subjects are plotted for comparison. These show the various heights of sensitiveness which different individuals ultimately reach, and also show in certain cases quite definite temporary arrests in the progress of adaptation (Do, B, Du, Hn, Fig. 3). Out of a total of fifty-two adaptation-curves plotted, fourteen showed this halt in the rise of sensitiveness very definitely, while in four others it is suggested. To emphasize this the first two curves shown in Fig. 3 are plotted together in Fig. 4, with their common origin at the point where adaptation begins and with the time-scale enlarged fourfold.

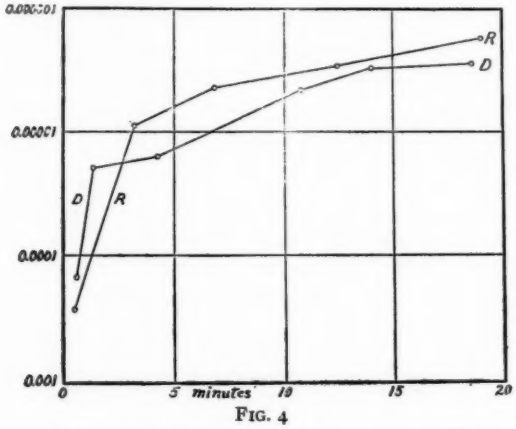


FIG. 4

In considering the rate of adaptation, that is, the individual rate of recovery of the sensitiveness temporarily lost in the process of blinding, it is to be said that great variation was found, but the most interesting fact is that the time of return to a fixed point in the scale of sensitivity (estimated from the plotted curve) bears no very definite relation to the ultimate degree of sensitiveness which the individual may show. There is perhaps a general trend, as might be expected, in the sense that a subject with a low absolute threshold reaches a given level of sensitivity more quickly and *vice versa*, but the exceptions to this are more noteworthy than the rule. In Fig. 5 are plotted the results from four types illustrating this. Subjects R and Si

have low absolute thresholds (high sensitivity), but R is slow and Si rapid in recovery. Similarly in the cases of W and Cr

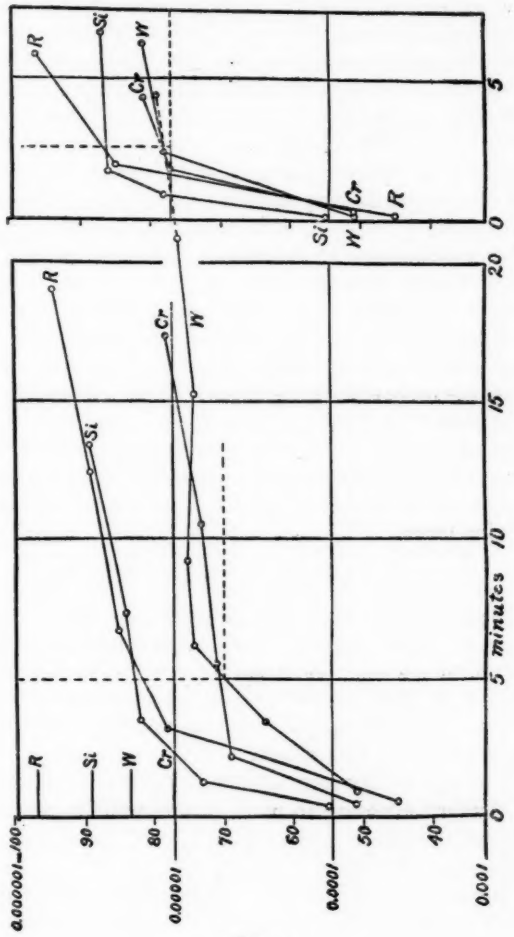


FIG. 5

whose absolute thresholds are, however, high. By examining the steep parts of the curves it will be noted that Cr at first re-

covers more rapidly than R, who is by far the more sensitive later on in the course of adaptation.

As to the general difference in the rate of recovery, as dependent upon the duration of the previous blinding, it is to be said that recovery is about three times as fast following the fifteen seconds' blinding as it is following the five minutes' blinding. The course is shown graphically in the right hand plot, Fig. 5, for the same four subjects. Owing to the rapidity of recovery the data are not as explicit as in the case of slower recovery.

The study of dark adaptation with reference to the practical use of the eyes at night involves a point of view different from that involved in the study of dark adaptation for the purpose of solving physiologic or diagnostic problems, and a question arises here, with especial reference to the aviator. In rating him, shall we consider his ultimate sensitivity, or shall we rate him in the basis of his speed of recovery after blinding? In other words, from this standpoint, which portion of the curve deserves the more exhaustive investigation? It would seem an obvious answer to this to say that the part of the curve to investigate is that which, in general, best represents the illumination conditions existing under natural light at night. The photometric study of such conditions will be a relevant and interesting topic.

SUMMARY OF EXPERIMENTAL CONCLUSIONS.

(1) Upon investigation of fifteen subjects, it appears that the limit of vision in dark-adaptation (the absolute threshold), measured by the least brightness at which gross form may be recognized, is variable within extreme limits expressed by the ratio of 7.4 to 1. These limits lie between 1 and 10 millionths of one candle per square meter.

(2) The rate of recovery, after dark adaptation is disturbed by a standard exposure to light, is also variable as between individuals, and by no means always in a sense corresponding with the value of the absolute threshold.

(3) Recovery to the point of visibility of a test stimulus 4.7 times the individual's absolute threshold is in general slower, the lower the absolute threshold. This seems to be the consequence of the simple fact that the test stimulus, so chosen, is necessarily the farther below the level of brightness of the

blinding surface, the lower the absolute threshold. The extreme individual variations in time for this relative degree of recovery are as 4.5 to 1, and as 2.5 to 1 for five minutes and fifteen seconds respectively.

(4) The time of recovery to the point of distinguishing a test object of standard brightness is to be looked upon as a function of two variables; the individual's absolute threshold and his rate of recovery as indicated under (3). For a constant test stimulus 4.7 times the (geometric) mean absolute threshold of all subjects, the extreme variations in time are expressed as 8.7 to 1, and 2.75 to 1 for the longer and shorter blinding periods respectively.

(5) The times of recovery are less diverse after a short blinding (15 seconds at 13 candles per square meter) than after a longer one (5 minutes, same), and in the former case recovery takes place on the average in about one third the time, or probably less when all antecedent conditions are equalized.

(6) The occurrence, in the course of dark-adaptation, of more or less definite arrests in the increase of sensitivity suggests the independent working of two physiologic mechanisms. These halts occur more or less definitely in eighteen out of fifty-two curves studied, and appear, when distinct, as "terraces" on the rising slope of the curve.

(7) The practical usefulness of data, such as the present, will depend upon a definite photometric knowledge of the minimum light-conditions under which the subject may be called upon to use his vision.

TABLE I.

	Absolute Threshold	AT −15mm.		70mm.		50mm. ±	
		Recovery time, seconds, after blinding for					
		5 min.	*15 sec.*	*5 min.*	*15 sec.*	*5 min.*	*15 sec.*
Largest value	9.95	385	106	542	99	62	25
Smallest value	1.34	86	43	62	36	10	5
Mean	4.97	214	71	233	73	34	12.6
Mean deviation	2.18	78	16	103	12	11	4.4

GENERAL RESULTS OF THE DARK-ADAPTATION EXPERIMENTS.

The absolute threshold is stated in millionths of one candle per square meter.

The next two columns give times of recovery, in seconds, of sensitivity corresponding to 4.67 times the subject's absolute threshold (AT − 15*mm*), for the five minutes and for the fifteen seconds' periods of blinding respectively.

Similarly, the next two columns (70*mm*) give the times of recovery to the point of visibility of a stimulus 4.67 times the (geometric) mean absolute threshold. This is 4.33 x 4.67 = 20.4 millionths, represented by 70*mm* in scale.

Under "50*mm* $\pm$," correspondingly, the times of recovery to a threshold of about 159 millionths, the initial result of parts 2 and 3 of the experiment as described in the text.

The times given under "AT − 15*mm*" and under "70*mm*" were estimated from the plotted curves, such as Figs. 4 and 5.

THE MADDOX ROD SCREEN TEST.[1]

By Captain PERE DOLMAN, M.C., Medical Research Laboratory, Hazelhurst Field, Mineola, Long Island, N. Y.

INTRODUCTION.

IT has been said by Colonel W. H. Wilmer, who established the Ophthalmological Department of the Medical Research Laboratory at Mineola, that the safety of the flier depends more upon good extraocular muscle function than upon good visual acuity. Under the stress and fatigue of flying, the aviator with hyperphoria or a divergence excess is apt to have his error become manifest as a diplopia which would make a safe landing nearly impossible. The symptoms (1) of headache, vertigo, and nausea, which commonly accompany some of the disturbances of motility of the eye are not compatible with the efficient service that is expected from the man who flies. For these reasons, the examination of the extraocular muscles must be conducted with the greatest care in the Air Service in order to uncover any defect which might jeopardize the life of the aviator.

During the past year several tests for the detection of heterophoria in the primary position were approved by the Ophthalmological Department of the Medical Research Laboratory. All of these except the Maddox rod screen and parallax tests were finally eliminated in an effort to reduce the ophthalmological equipment to a compact war basis. In the course of the examination of hundreds of men, the Maddox rod test, because of its great simplicity and easy application, was es-

[1] Presented by invitation before the American Ophthalmological Society, June, 1919.

tablished in a favored position to the partial exclusion of the other tests.

At this stage of the laboratory work, several of the examining surgeons began to question the accuracy of the Maddox rod test. The evidence submitted by them showed that some aviators could not see the light and the line at the same time; that others saw the line of light moving about so erratically that no measurements could be taken; that still others showed a tendency to fuse the line with the light, indicating orthophoria when some form of heterophoria was known to be the true condition.

CRITICISMS OF THE MADDOX ROD TEST.

A review of American ophthalmic literature reveals many criticisms of the Maddox rod test which support these observations. Duane (4), in discussing the routine examination of the eye, says that the test is not as reliable in his hands nor as accurate as the screen and parallax tests. He finds it is apt to indicate an excess of esophoria and a tendency in some patients to fuse the line with the light. Later (5), he repeats this criticism and estimates the amount of excessive esophoria shown by the test to be about one degree. Howe (7), in his elaborate study of the eye muscles, places the Maddox rod third in the list of tests arranged according to their clinical value. In analyzing some tests for heterophoria, Stevens (11) finds that the tendency of the line to fuse with the light is so great that orthophoria is often shown when heterophoria exists. Weeks (13) calls attention to the fact that some patients have difficulty in seeing the line of light. On the basis of some comparative tests, Weymouth (14) concludes that the Maddox rod showed an excessive amount of esophoria.

In spite of all this authoritative criticism of the test, the Maddox rod continues in general use. It is to be found in almost every trial case and is included in the equipment of most of the new combined phorometers. When we consider that studies of heterophoria, based wholly or in part on this test (3, 10), are being added constantly to our ophthalmic literature, it becomes a matter of importance to determine its accuracy. This experimental work was begun for the purpose

of investigating these criticisms of the Maddox rod test, analyzing the causes back of them and suggesting, if possible, some remedial procedure.

CONTROL TESTS, OBSERVERS, AND APPARATUS.

The screen and parallax tests, recommended by Duane, were used as control tests. The observers were chiefly aviators with normal visual acuity and normal-functioning ocular muscles. The apparatus used was DeZeng phorometer-trial frame, equipped with a pair of Maddox rods and a pair of Risley rotary prisms. The spot of light was obtained from a frosted Mazda lamp surrounded by an opaque chimney. An iris diaphragm in the chimney permitted the size of the spot to be regulated. This lamp was mounted on a movable floor standard, which could be adjusted for height. The tests were made with the eyes in the primary position looking at the light twenty feet away. For the purpose of some experiments, a condition of artificial heterophoria was produced by placing a trial case prism in the trial frame of the phorometer. This prism was always placed before the eye that was covered by the Maddox rod. When necessary to study the effect of reduced visual acuity, convex lenses were placed before one or both eyes. The effect of accommodation on the test was studied by placing concave lenses before one or both eyes. In the following report "the light" or "the spot of light" refers to the light twenty feet away at which the observer looked during the test; "the line" or "the line of light" refers to the line of light seen by the observer when looking through the Maddox rod.

SCOPE OF THE INVESTIGATION.

For the purpose of study, the criticisms of the Maddox rod test were grouped under four heads:

I. Excessive esophoria.
II. Fusion tendency.
III. Instability of the line.
IV. Inability to see the line.

I. *Excessive Esophoria.*—One hundred men were examined for the purpose of determining if the Maddox rod test does

actually show more esophoria than the screen and parallax tests, which were employed as controls. An analysis of the result of the examination gives seventy-two men who have ½ to 2 prism diopters more esophoria or less exophoria by the Maddox rod test than by the control tests.

This fact being established, a study of the various factors entering into the test was made for the purpose of discovering the possible causes of the excessive esophoria. The factors were gradually eliminated by experiment until the following two remained:

1. Latent hypermetropia.
2. False projection of the line.

1. *Latent Hypermetropia.*—A group of emmetropes, free from heterophoria, was selected for the purpose of determining the effect of artificial hypermetropia on the Maddox rod test. With the Maddox rod in place before one eye, a one diopter concave lens was placed before the other eye. The test registered esophoria immediately, showing that the light-fixing eye, which was covered by the lens, controlled the finding. On removing the lens the test showed orthophoria. On placing it before the eye covered by the Maddox rod, the test still registered orthophoria, showing that the light-fixing eye still controlled the finding. With the lens still in place before the eye covered by the Maddox rod, the observer was urged to concentrate his attention upon a line and disregard the light. After considerable effort he was able to focus the line through the concave lens and the test registered esophoria immediately. The accommodative effort necessary to do this, however, was so much greater than the effort necessary for light fixation that at the first wavering of attention from the line, the light was again fixed and the test showed orthophoria. The addition of a great variety of lenses to one or both eyes of the observers used in this experiment confirms the conclusion that a hypermetropic condition of the light fixing eye, by stimulating accommodation and convergence, always effects the findings of the test in favor of esophoria. A hypermetropic condition of the eye covered by the Maddox rod does not influence the result of the test unless fixation is switched from the light to the line.

Attention is now called to the fact that persons with unequal, uncorrected hypermetropia usually use the eye with the lesser refractive error for the purpose of clearest vision. If this eye with the lesser amount of hypermetropia be covered by the Maddox rod, the result of the test will be based upon the greater amount of hypermetropia in the light fixing eye. Such a finding will show more esophoria than actually exists.

The experiment emphasizes the necessity of having the patient wear his refractive correction during the test for heterophoria.

2. *False Projection of the Line.*—Some observers apparently see the line of light nearer than the source of light twenty feet away. On being questioned they are apt to say that the line passes in front of the light. The recorded answers of fifty observers show that not one thought the line was as far away as the light. Some saw the line a few inches from the face. The majority projected it from three to ten feet away. It is not possible for an observer to give close attention to an image which he believes is ten feet away without making some effort to focus his eyes for that distance. Peterson (9), in analyzing a distant light phenomenon, says, "Normally in spatial perception our focus is on the object which received the attention." If the observer visualizes the line nearer than twenty feet and focuses upon it where he imagines it to be, the accommodative effort he makes produces a convergence which in turn increases the amount of esophoria.

The experiments made in studying the false projection of the line indicate that it is more apt to occur if the line is seen indistinctly. A reduced visual acuity, for example, causes the observer to try to bring the line into sharp focus, which results in esophoria if he is able to make any accommodative effort. An indistinct line, caused by irregularities in the surface of the glass of the Maddox rod, produces the same effect. A large number of Maddox rods have been tested for such defects and for prism. A separate report will be made on these defective rods.

The natural precaution to be taken against false projection of the line is to keep the observer's attention fixed on the light as completely as possible during the test.

II. *Fusion Tendency.*—There are little data available on the

subject of the fusion of more or less dissimilar retinal images. It is not known how dissimilar the two retinal images must be in form, color, and distinctness to prevent fusion. In addition, I can find no record of any experimental work done on the fusion tendency as distinguished from actual fusion.

The present investigation has determined that the spot of light and the line projected by the Maddox rod form retinal images, sufficiently dissimilar in form to prevent actual fusion in the measurement of esophoria and exophoria. An apparent fusion in the measurement of hyperphoria is shown in a number of the tests.

It has been demonstrated by the experiments that the fusion tendency is increased by certain conditions which may surround the Maddox rod test. They are:

1. The exclusion of extraneous retinal images.
2. Horizontal and vertical lines in the background.
3. Additional sources of light.
4. Intensity of the point of light.

1. *The Exclusion of Extraneous Retinal Images.*—When the room, in which the test is being made, is darkened so completely that the light and the line are the only two outstanding sources of retinal stimulation, the fusion tendency is very strong. The light and the line are double images in the truest sense, causing confusion and interfering with vision. The natural reaction of the observer to this unusual condition is to avoid the double images, by an attempt at union or fusion (6).

When the room is not darkened during the test, the eye fixing the spot of light is diverted by the extraneous images of numerous objects and outlines in the background. The line and the light now of lessened brilliancy, are no longer the only sources of retinal stimulation and the fusion tendency is decreased. Exceptions to this conclusion are considered under the next two captions.

2. *Horizontal and Vertical Lines in the Background.*—The line of light fuses readily with horizontal and vertical lines situated near the point of light (12). The vertical lines of door and window casings, cabinet edges, etc., even when situated twelve inches or more away from the spot of light, may be fused with the line of light. The most vicious of these lines is the one projected by the vertical standard made to support

the lamp used in the test. This form of light equipment, which is manufactured particularly for the purpose of ocular tests, has escaped general suspicion. One was in use in this laboratory for several months before attention was directed to this inherent fault and its construction.

3. *Additional Sources of Light.*—The spot of light arranged for the purpose of the test should be the only source of illumination visible to the observer. Other sources of illumination, such as overhead lights, table lamps, and partially shaded windows, are seen through the Maddox rod as supernumerary lines of light, any one of which may be fused with the spot of light and give a false finding.

4. *Intensity of the Point of Light.*—When the spot of light is very brilliant, an intensely bright line is formed and the fusion tendency is then greatly increased. This is particularly true where the room in which the test is conducted is dark. A spot of light of very moderate intensity is sufficient for the purposes of the test in a semi-darkened room.

The effort to see the line and the light simultaneously naturally stimulates the fusion tendency. When the observer concentrates his attention upon the light and disregards the line as much as possible, no movement of the two images takes place to indicate a fusion tendency. The same is true when the observer's attention is concentrated upon the line to the exclusion of the light.

III. *Instability of the Line.*—In the Maddox rod test for esophoria and exophoria, the line is frequently observed to lack stability. Instead of being in a fixed position in the background, it is seen in a constantly varying lateral relation to the light. Patients speak of this phenomenon as a "wavering" or "dancing" of the line. A similar movement of the light is merely observed. This is due to the fact that the light is seen in its proper relation to other objects in the room. The eye covered by the Maddox rod, however, sees no objects in the room which help to give the line a fixed position. For this reason, any change in the lateral distance between the light and the line is interpreted as a movement of the line alone.

The experimental study of this phenomenon demonstrated that the movement was checked when the observer concentrated his attention and fixation on the light and at the same

time disregarded as much as possible the image of the line. Similarly, the movement was checked when the line was fixed and the image of the light disregarded. It follows from these facts that movement of the line may result from an effort to fix both the light and the line at the same time or as a result of fixation which alternates between the light and the line.

In simultaneous fixation the movement may be due to:

The fusion tendency.

In alternating fixation it may be due to:

1. Unequal hypermetropia.
2. False projection of the line.

The influence of these factors on the test has already been discussed so completely that their relation to instability of the line is apparent.

The data collected in this investigation indicate that another cause of movement of the line may be connected with the habitual use of one eye for fixation purposes. This phase of the investigation will be made the subject of a separate report.

IV. *Inability to See the Line.*—The causes of failure to see the line in the Maddox rod test are usually simple and self-evident. They are reviewed here chiefly for the purpose of completing this critical study of the test. They may be grouped as follows:

1. Malposition of the Maddox rod.
2. Bright illumination of the room.
3. Dimness of the spot of light.
4. Non-essential sources of light.
5. Poor vision in one eye.
6. Habitual suppression of one image.
7. Poor vision in both eyes.

1. *Malposition of the Maddox Rod.*—The single Maddox rod must be very carefully adjusted in front of the eye to bring the line in the field of vision. Some of the newer multiple rods, because of their small diameter, require unusual care in adjustment. A more distinct line is always secured when the rod is placed close to the eye.

2. *Bright Illumination of the Room.*—If the test is made in a brightly lighted room, the line is not easily seen in contrast with the surroundings. In a very dark room both the light

and the line are seen more distinctly but the manipulation of the apparatus is accomplished with unnecessary difficulty. The test is best made in a semi-darkened room.

3. *Dimness of the Spot of Light.*—A bright source of light, diffused by ground or milk glass, is most suitable for the test. Such a light, when screened down to a diameter of from 8 to 10*mm*, will irritate the eyes very little and will be seen through the Maddox rod as a line bright enough to be distinguished easily in a semi-darkened room.

4. *Non-essential Sources of Light.*—When sources of light, non-essential to the test, are located in front of the patient, several lines of light may be seen through the Maddox rod. The particular line belonging to the spot of light often is not located under these conditions and the test is completed with the wrong line.

5. *Poor Vision in One Eye.*—The eye covered by the Maddox rod may have such poor vision that the line cannot be seen distinctly. The obvious remedy is to place the rod before the better seeing eye.

6. *Habitual Suppression of One Image.*—When the image of the non-fixing eye is habitually suppressed, the Maddox rod test fails because the test depends upon the relation between two images which must be seen at the same time.

7. *Poor Vision in both Eyes.*—When the visual acuity of both eyes is greatly reduced, the test may fail entirely because neither eye, when covered by the Maddox rod, can see the line distinctly.

While this experimental study was in progress, the data collected from day to day were analyzed for the purpose of discovering some common cause of the excessive esophoria, the fusion tendency, and the instability of the line, which constitute the chief criticisms of the Maddox rod test. The conclusion was reached that these faults depend chiefly upon the effort of the observer to fix both the light and the line at the same time or to alternate his fixation between them. It was but another step to apply the screen to the test as a means of controlling the observer's fixation. The use of the screen to cover the eyes alternately, as in the screen and parallax tests, obviously would not help here because alternate fixation was causing part of the error. The choice then lay between per-

mitting the observer to fix the light or to fix the line during the test. Line-fixation was regarded as objectionable because it induced false projection in some cases. It seemed better to consider the line as a false image, the position of which was to be determined in relation to the light. This view of the test definitely gave the rôle of fixation to the eye which sees the light and directed that the screen be used to prevent line-fixation.

I am able to find but one reference to the use of a cover in connection with the Maddox rod test (4). No originality is claimed for the general idea, but the technique of the test, as worked out in the laboratory, is probably sufficiently new to warrant a detailed description of the procedure.

THE MADDOX ROD SCREEN TEST.

(At Six Meters.)

The observer is seated facing the light, which is at the height of his eyes and six meters distant. The Maddox rod may be held in position by a trial frame and the measurements made with square prisms or those found in the trial case. The test is much simplified and greatly facilitated by the use of a modern phorometer-trial frame, equipped with a double multiple Maddox rod and a double Risley rotary prism. This apparatus is brought closely in front of the observer's eyes and adjusted to a horizontal position by means of the spirit level. The phorometer is not used to measure the amount of heterophoria because its binocular prisms deflect the visual axes of both eyes and consequently leave neither one in the primary position. Both the Maddox rod and the rotary prism are swung into position before one eye, allowing the other an unobstructed view of the light. It is a good idea to set the rotary prism 4 △ or 5 △ off the zero mark in order to deflect the line at the beginning of the test. This will serve to expose any one who has been coached to say that the line passes through the light.

A card about 6 x 9*cm* is used as a screen. This is moved from one eye to the other a few times to ascertain if the observer sees both the line and the light. If the line is not seen readily,

the Maddox rod is readjusted by centering it carefully in front of the pupil. Some further darkening of the room may be necessary to render it visible.

When the observer sees both the line and the light easily, the test is begun by holding the screen in front of the Maddox rod to shut out the image of the line. The observer now sees only the light. After he has fixed it for several seconds, the screen is removed for an instant and quickly replaced. In that brief interval the observer should see the line and be able to locate it with reference to the light. After one or two brief exposures, he will be able to say in a test for lateral imbalance that the line is to the right or left of the light or possibly through it. He is then instructed to grasp the milled head that rotates the prism and turn it to bring the line directly through the light. To enable him to do this, the screen should be removed from the eye at intervals and quickly replaced. Finally the observer will have rotated the prism enough to cause the line to pass through the light every time he sees it when the screen is removed. The number of prism diopters necessary to deflect the line through the light is read from the scale of the rotary prism.

The results of the test will be more accurate if the eye that fixes the light is in the primary position and not deflected from it by a prism. It is for this reason that the measuring prism is placed always before the eye that is covered by the Maddox rod. The Risley rotary prism is convenient because it enables the observer to make the necessary prism correction himself.

Attention is called to certain merits of the procedure described. One eye is permitted to fix the light while all vision of the line by the other eye is prevented except for brief intervals. The eye under cover takes a position that is influenced by a minimum of the innervation habitually required for binocular vision (2, 8). The removal of the screen can be done so rapidly that the image of the line fails to stimulate the retina enough to cause readjustment of the visual axes in the interest of binocular vision, yet the exposure is long enough to permit the line to be seen for the purpose of the test.

The test offers one very interesting variation. Either the right or the left eye may be selected to fix the light. Each individual can thus be tested in two ways and two sets of measurements be obtained. The variation in these double

findings and the relation of the "sighting" or "dominant" eye to the test are being studied and will be made the subject of a later report.

Experiments lasting several months demonstrate that this test is more accurate than the accepted Maddox rod test. The results obtained with it are identical with those of the screen and parallax tests. This high degree of accuracy, combined with the simplicity and rapidity of application of the test, has caused its adoption by the Medical Research Laboratory.

CONCLUSIONS.

1. The Maddox rod test, because of its easy application and the simple nature of the observation required, enjoys a popularity and widespread use among ophthalmologists.

2. Studies of heterophoria, based wholly or in part on Maddox rod findings, are constantly being reported in ophthalmic literature in spite of some serious criticisms of the test.

3. The test has been condemned chiefly because it shows excessive esophoria, a tendency to fusion, and an instability of the line of light.

4. These faults of the test have been verified and the underlying causes determined.

5. The Maddox rod screen test, a simple modification of the usual procedure, gives results that are accurate and free from the above criticisms.

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REPORT OF THE ANNUAL CONGRESS OF THE OPHTHALMOLOGICAL SOCIETY OF THE UNITED KINGDOM.

By Mr. H. DICKINSON, London.

The Society held its Annual Congress in London on May 1st, 2d, and 3d, under the presidency of Mr. J. B. Story (Dublin).

The President expressed his high appreciation of the honor conferred upon him by his colleagues in electing him to fill the chair of the Congress. The Society, he said, was much indebted to its past-presidents, and to none more than Mr. Treacher Collins, who steered the barque of their fortunes through the stormy weather of the last years of war: it was largely due to him that the last Congress was such a success. On that occasion the discussion on plastic surgery of the eyelids excited very great interest, and the exhibition of cases, photographs, and casts made a deep impression on those privileged to attend the meeting, or who visited the Plastic Hospital at Sidcup. The same subject had been chosen by the Bowman Lecturer this year, Professor Morax. The discussion also on contagious diseases of the conjunctiva, held at Swanley, was also a pleasant and important feature of last year's Congress. He also expressed satisfaction that the Oxford Ophthalmological Society and the Midland Ophthalmological Society had become affiliated with the larger body. He was now happy to state that three other societies had now been affiliated: the North of England, the Egyptian, and the Irish. Among the deaths during the past year, he wished to specially mention four, two of them original members—Dr. John Cooper and Dr. Thomas Buzzard; Mr. Devereux Marshall, who died in Bombay on active service, of cholera. He believed Mr.

Marshall was at one time Secretary of the Society, and he had served on its Council. Another whose name he would mention was Sir James Mackenzie Davidson, whose work on the localization of foreign bodies in the eye by means of X-rays was familiar to all. He concluded by a reference to the special subjects for discussion at the present Congress.

On the initiative of Sir Anderson Critchett, the President was cordially thanked for his address.

Mr. TREACHER COLLINS read a paper on **abiotrophy of the retinal neuro-epithelium,** or **retinitis pigmentosa.** He pointed out that the pathological examination of several eyes with retinitis pigmentosa had shown that the affection might occur without sclerosis of the choroidal blood vessels, and that the primary change appeared to be a degeneration of the rods and cones. As the condition is hereditary, he suggested that the degeneration might most aptly be described as an abiotrophy. From this standpoint, its various accompaniments might be explained as follows: The increase in the neuroglia of the retina is similar to that met with in various forms of neuronic abiotrophy, and not like what occurs in sclerosis where there is an increased firmness in consistency. Secondly, the pigmentation of the retina is caused by the degeneration of the rods and cones together with their attached nuclei, leaving spaces in the membrana limitans externa, through which the pigment epithelial cells, or their pigment granules, can migrate. Such migration he considered was probably due to the physiological capacity for movement in the direction of light which these cells and granules possess. The light-colored dots sometimes seen in the retina, and the hyaline nodules occasionally met with on the optic disk, are of the same nature, and are due to hyaline degeneration of cells derived from the outer layer of the secondary optic vesicle, from the pigment epithelium overlying the choroid, and the neuroglia in the optic papilla. In typical cases the degeneration of the neuro-epithelium commences where it is first fully developed, *i.e.*, around the macula, which, being last developed, is last involved. This is why sight begins to fail in the form of a ring scotoma. Night-blindness, the earliest symptom, is due to the failure of vision commencing in the part of the retina which, in the dark-adapted eye, is the most sensitive to light, that is 10° to 20° from the fovea. Atypi-

cal cases of retinitis pigmentosa occur in which the macula alone is involved. There being no blood vessels at the macula, there are, in these cases, no branching pigment patches, only scattered dots and granules of pigment. The deafness and affections of the nervous system met with in association with retinitis pigmentosa are also due to abiotrophy.

Professor HERBERT PARSONS remarked on the danger of labeling a diseased condition with a particular term, and considering that this explained it: even if it were an abiotrophy, one had to get behind that and try to ascertain the causation. He did not think it would be difficult to oppose arguments to each thesis set up by the author, if there were time.

Sir ANDERSON CRITCHETT spoke of the way subjects of retinitis pigmentosa were helped by wearing yellow glasses. He asked whether members had had experience of Crooks glasses (which take out the purple rays) for this condition. The subject was also discussed by Mr. R. GREEVES and Mr. M. S. MAYOU.

Mr. GEORGE YOUNG read a paper on **results of double sclerectomy operation for glaucoma.** The paper was founded on twelve cases. The reduction in tension had been, so far, permanent; there had been no bad results over periods of several months to two years. The incision must be as near the limbus as possible, and he emphasized the necessity of making a second opening. It was not disfiguring and there were no relapses.

The PRESIDENT considered the operation easy compared with other procedures.

Lieut.-Colonel HERBERT contributed a paper on **the future glaucoma operation.** He said that in India cases of glaucoma were always far advanced when seen, and he had been driven back to the iris prolapse operation. An incision was made by puncture and counter-puncture, with a *1mm* Graefe knife; the incision was entirely subconjunctival. In advanced glaucoma the incision could be safely made of almost any size. This operation was free from the disasters which might attend iridectomy for the condition. The whole operation could be performed without emptying the anterior chamber, and its chief feature was the sufficient widening of the filtration area. He described the technique in minute detail.

Mr. R. R. CRUISE read a paper on **contracted sockets,** in

which he described a procedure to enable a socket which had been disorganized by injury to hold a glass eye.

Mr. C. HIGGENS showed a number of soldiers on whom he had performed various operations for the same purpose, and demonstrated the procedure followed in each case.

Mr. W. SINCLAIR discussed **eye complications in cerebro-spinal meningitis,** and Mr. PERCIVAL J. HAY read a paper describing some new test-types.

Discussion on Visual Requirements of Aviators.

On Thursday afternoon members assembled at the Psychological Laboratory, University College, where a discussion was held on the subject of **visual requirements of aviators.** Professor SPEARMAN delivered an address on stereoscopic vision, which had been decided by many people, including Americans, to be the most important factor in the visual fitness of aviators, especially in regard to successful landings, a source of much mortality among fliers. He divided his remarks into (1) a method of testing stereoscopic vision in candidates, (2) suggestions as to means of improving the vision of aviators. This faculty had to be differentiated from quasi-stereopsis or the power of appreciating depth, and which depended on the clues at the disposal of either eye alone. In stereoscopic vision, each eye had to form a good image, and that depended, principally, on the optical excellence of the iris. It seemed to be considered that for binocular vision all that was required was for both eyes to function, instead of only one. But there was only one visual field in consciousness, though there were two ocular fields, and both ocular and conscious fields could not function with regard to the same spot at the same time. It was seldom that both eyes acted simultaneously; that was sometimes due to asymmetrical astigmatism. It was important to try to find out how the ocular movements tested the balance of muscles. The eyes took up the right position for clear-seeing if given plenty of time, but it did not necessarily follow that they would do so when speed was essential. A test embracing the following of a moving field was therefore necessary.

Mr. A. R. BRAILEY tabulated his results in the ocular examination of about four thousand candidates for the Air Ser-

vice. The visual standard was, at first, very high, but later it was somewhat relaxed, and the fitting of lenses to the flying masks was permitted, and they proved quite satisfactory. Some officers asked for a difference in the shape, and others requested tinted glasses on account of glare. The lowest vision permitted was $\frac{6}{12}$ with the better eye, $\frac{6}{24}$ with the worse, corrected by glasses to $\frac{6}{6}$ and $\frac{6}{9}$ respectively. Binocular vision and a good sense of perspective were not always found to go together. No rejections were made on account of faults of muscle balance, apart from actual squint. Flying failures were not found to be more numerous among the wearers of glasses than among others. Perception of the parallactic movement of objects he regarded as the all-important factor, but this he had found it difficult to assess by any test. When making a landing at a high speed, it was difficult to see the details of objects, and in that operation he did not think stereoscopic vision could be of great assistance in that. Little could be done in the way of correction of muscle defects by any form of training, however continuously carried out. Before candidates were accepted, details of their heterophoria should be available, both before and after treatment. For this Service, a more important matter than acuity of vision in itself was the precision and rapidity of coördination between eye and brain: it was useless for a man to see perfectly unless he could accurately interpret, and act quickly in accordance with his perception. Fliers could not be selected by medical examination alone, any more than an efficient cricket team could be so selected from among the boys in a school: in flying, pluck, resource, and response to stimuli were more important than medical perfection, especially in war time. Still, medical examination was important in regard to stress and fatigue, especially at high altitudes. Standards of light and color sensibility should be set up, so that parents could know, years beforehand, whether their sons were likely to attain to them. One very successful flying man in the Service had 5 D. of myopia in each eye, and—probably as a result of wearing glasses—he had but indifferent binocular vision. A too stringent standard would exclude many otherwise desirable men.

Major CLEMENTS said 26% of the men who came under his observation had glasses ordered, and they were turned down

on account of bad landings. He described in detail the tests he employed, and the results obtained. Of 294 men, 60% who were rejected on account of having made bad landings had been in clerical or other close occupations. He had much of interest to say as to actual flying: the way in which the aviator knew whether he was flying level, and demonstrated the importance of good peripheral perception. The good flier looked at his horizon and used the nose of the machine as a protractor for measuring the flying angle.

Professor J. H. PARSONS spoke of the need of research in this matter, of which the work done by Professor Spearman was a good example. This was the more needed on account of the already large amount of literature on the subject, too large a proportion of which was merely speculative. One of these important questions was that of heterophoria, and researches on the subjects coming within the scope of the present discussion should be against controls, as was the case in any well-conducted scientific inquiry.

Mr. ERNEST CLARKE spoke of the importance of testing under hom-atropine in every case in order to exclude latent hypermetropia. Nearly all the men he had examined because they had crashed had hypermetropic astigmatism, but they had been passed as what was termed "practically normal."

Colonel FLACK referred to the large range of capacity in candidates for the Service, and said that two very important questions had to be asked in this connection: (1) was he likely to acquire the art of flying? (2) was he likely to be able to stand the wear and tear of flying? He emphasized the point that a man with good arm and leg movement and coördination might fly successfully even though he might not have perfect vision. In regard to the second point, if a man's vision could be easily deteriorated by fatigue, that was a man one had to watch. But men's eyes could be greatly improved by rest and training. He thought a military pilot should have visual tests at varying altitudes for a period of at least one hour: an ophthalmic specialist should be there to test the vision. Even then much would remain to be settled. He thanked Professor Parsons for his suggestion as to research on this subject.

(*To be concluded in the November number.*)

REPORT OF THE PROCEEDINGS OF THE SECTION ON OPHTHALMOLOGY NEW YORK ACADEMY OF MEDICINE.

By ELLICE M. ALGER, M.D., Secretary.

MONDAY EVENING, MAY 19, 1919. DR. ARNOLD KNAPP, CHAIRMAN.

Dr. M. J. Schoenberg presented a patient, one of whose eyes had been previously removed for **glioma**, while a subsequent growth in the second eye had been apparently arrested by the X-ray and radium. (For full report see page 485.)

Discussion: Dr. H. H. Tyson had had a similar case in which this method of treatment, however, had not been permanently successful. Dr. Arnold Knapp thought that this was a very important case because retinal glioma is bilateral in about twenty per cent. of the reported cases, and permission to enucleate the second eye can very rarely be obtained. Dr. A. E. Davis thought the present appearance of the eye strongly suggestive of syphilis and inquired if this had been excluded, and in reply Dr. Schoenberg said he excluded it because there were no other indications of that disease and because the serological reaction of both parents was negative. The tuberculin reaction was also negative. It must be admitted that the choroidal changes near a glioma were unusual. The cataract was not there before the second radium treatment which lasted eight hours, and was probably the result of the treatment, as the face was burned as well.

Dr. George H. Bell presented a patient with **angioneurotic œdema,** who first came to his clinic at the New York Eye and Ear Infirmary on May 10, 1919. When first seen there were marked œdema and swelling of eyelids, upper and lower, and

big bags under both lower lids. Also the lips and throat were swollen, and the patient at times had great difficulty in breathing. This swelling of eyelids was sharply defined and did not pit on pressure. The attacks passed away in twenty-four to thirty-six hours and left the patient all right until another attack. He has had the trouble seventeen years. Urine normal. Blood pressure normal. The patient attributed the attacks to changes in the weather, but Dr. Bell thought that they were due to some protein toxin.

Dr. GEORGE H. BELL presented a drawing of a **cutaneous horn** 14*mm* long of the lower lid, regretting that he could not present the patient. These horns are very rare, and this was the second one seen by him in twenty years.

Dr. C. E. MCDANNALD presented a **twin child with interstitial keratitis,** first seen and reported several years ago, which had recently had a recurrent attack. The unusual feature was that the child's mother and the child itself had from the first positive blood Wassermann reactions, while the father and the other twin have been both clinically and serologically free from any sign of syphilis. Dr. McDannald offered no explanation of the unusual condition. The mother had been previously married but nothing was known of the history of the first husband.

DISCUSSION: Dr. CUTLER suggested that a provocative salvarsan might reveal disease in the healthy twin. Dr. SCHOENBERG suggested that the child might have been infected after birth and that both father and the other twin might be syphilitic in spite of the negative Wassermann reactions. He deprecated a provocative salvarsan as not devoid of danger.

Dr. H. H. TYSON presented a patient with **spontaneous pulsating exophthalmus.** Recovery without operation.

Mrs. B. N. B., aged 43 years, was referred to him on June 29, 1918, on account of proptosis of her left eye, with the history that five weeks previous she had had a severe pain behind her right eye and on the right side of her head, with surging through her head from side to side synchronous with her pulse; and also had pain in her left ear, the pain finally localizing behind her left eye. About one week previous to visit she had noticed that her left eye began to protrude with slight fullness

behind her left ear. Examination: veins of upper lid were dilated, pulsation obtained, blowing bruit over both eyes, marked over left eye. Chemosis ocular conjunctivæ appearing above lower lid in palpebral fissure, left eye fixed in median line, very slight motility, marked exophthalmos left, diplopia variable in all fields. Tn. pupils dilated with sluggish reaction to light, consensually and on attempted convergence. Fundi slight congestion of retinal veins. Following report from Dr. GOLDHORN, Mt. Vernon Hospital, who also prepared the photographic negatives presented, showing condition at that time: Urine 1018, negative. Wassermann negative. Spinal fluid and gold globulin negative. Sinuses negative, B. Pr. 160 to 190—X-ray showed prominent vessels on left side of brain due to intense congestion. Neurological examination by Dr. L. P. Clark negative. Vision with glasses O. D. $\frac{20}{100}$, O. S. $\frac{20}{70}$ Comp. myopic astigmatism. No history of trauma obtainable. The only possible cause determined was strain caused by rather violent effort at singing, in trying for high notes; as the pain behind left eye followed shortly after.

A diagnosis of spontaneous pulsating exophthalmos due to arteriovenous aneurysm in the cavernous sinus was made and ligation of the left common carotid was advised. She entered the Mt. Vernon Hospital with the intention of having the operation performed, but on account of the objection of some members of her family, later the operation was refused. She remained at the hospital under observation and treatment of Dr. Quinn, her family physician, and I examined her eyes on several occasions. For ten weeks the treatment consisted of rest, diet with digital compression of carotid for a time, and sodii iodid internally. On July 12th, extensive chemosis was present with portion of left ocular conjunctiva resting upon the cheek. Ophthalmoplegia totalis with paralysis of seventh cranial nerve with small retinal hemorrhage in fundus O. S. On September 10th, punctate retinal hemorrhages O. S. Pupils react to light sluggishly. Chemosis conjunctiva on temporal side and inferiorly, bruit heard all over head, loudest and lowest tone heard over left eye. Feeling much better, facial palsy improved. Cornea clear Tn. B. Pr. 168. May 14, 1919. Vision with glasses O. D. $\frac{20}{30}$, O. S. $\frac{20}{50}$. B. Pr. 180. O. S. fundus, pallor left optic nerve (partial pressure atrophy) ret-

inal pigmentation due to former hemorrhages. Tn. slight chemosis inferiorly and near outer canthus, slight diminution of motility outward (abducens paresis) contraction of color field about one half. No bruit upon auscultation nor pulsation obtained. Feeling very well. No noises in head nor vertigo. Noises stopped about two months ago. As she has not been receiving any treatment nor medication for the past six months we have what may be considered a spontaneous curve, as although the previous treatment and medication may have had some beneficial effect there has been an interim of six months with no treatment.

Dr. A. E. DAVIS presented a child with **tuberculosis of the choroid.** She was first seen six years before when she showed a spot of choroiditis near the macula of the left eye. A von Pirquet at this time was negative and the child consequently placed on antisyphilitic and tonic treatment which was not effective. A few weeks later she sustained a trauma which ruptured the choroid of this eye in the macular region, and soon after was lost sight of. Six years later she reappeared with the history of severe headache and nausea with blurring of vision in the other eye, which was reduced to $\frac{1}{10}$. A grayish area could be seen below the macula and there was a paracentral scotoma above. A von Pirquet at this time resulted in slight rise of temperature and there was a reaction on the arm and in both eyes. One mg. of O. T. resulted in a marked local, focal, and general reaction, while subsequent treatment with therapeutic doses of tuberculin had caused marked improvement in vision. Dr. DAVIS also showed a child of five years with **double congenital ptosis** on which he had recently done the de Grandmont operation. Three millimeters of the cartilage, skin, and orbicularis were removed from the left lid and two and a half from the right and the wounds closed by interrupted sutures reaching entirely through the lids. His experience with the de Grandmont operation had been very favorable, as this case shows, and he had never seen an over-effect even when rather large sections of cartilage were removed.

Dr. ARNOLD KNAPP presented a case of **spontaneous reduction of tension in glaucoma.** A little girl 12 years old, with a myopia of 7 D. was first seen, in the fall of 1917, vision being

R. $\frac{20}{200}$, L. $\frac{20}{100}$. The pupils are a little excentric. The depth of the anterior chamber was not uniform with a slight tremulousness of the iris, suggesting a partial subluxation of the lens. The circumcorneal part of the sclera was blue, the field being contracted to 10°. The optic nerves were cupped, with pronounced atrophy. Tension from 60–70.

She had one brother who is also myopic with a tension varying between 28–40, with normal sight and a normal eye ground.

The right eye was operated upon, followed by a retrochoroidal hemorrhage, prolapse of vitreous, subsequent phthisis, and enucleation. The left eye, with the very bad experience which was had on the right eye, was treated with drops. The tension in January, 1918, was 36 and then gradually went down until in November, 1918, it was 13, at which it has remained up to the present time. To-day vision with glasses was $\frac{20}{200}$. She had a shallow anterior chamber. The optic nerve showed no cup but is very white.

The case was of interest as showing a glaucoma which apparently was secondary to a partial subluxation of the lens, and that these eyes do not stand operation well and, further, that by leaving them alone or by means of drops the tension may be satisfactorily reduced.

Dr. P. B. HOUGH showed a child of one year who, since the second month had presented a small but gradually increasing **orbital tumor.** This is situated at the juncture of the frontal ethmoid suture and was about 6*mm* long and 3*mm* wide. At first it was of bony consistency, immovable and with no signs of inflammation. Recently the mass had increased at least a third in size and become cystic in character. The points of interest were the early hardness, the very slow growth, and the later sudden change in character and rapidity of increase.

Dr. J. WOLFF thought it was almost certainly a dermoid tumor.

Dr. E. M. BLAKE presented a child with a **cilium in the anterior chamber.** There had been a trauma with prolapse of the iris at the limbus, which had been excised and covered with conjunctiva, the cilium not being visible till the wound had healed. As there was not the slightest sign of irritation the general consensus of opinion was to leave it undisturbed.

Dr. I. GOLDSTEIN presented for Dr. J. E. Weeks the following cases.

Case 1. **Maculo-anæsthetic leprosy of brow and cornea.** Male, 30 years old, parents are perfectly well, Russian; occupation, rag picker; ill six years. Upon the eyebrow of left eye are four or five round macules, of brownish red hue, the centers of which are white and depressed, while the borders are elevated and colored. Macules are anæsthetic. Ocular conjunctiva injected on temporal side and extending somewhat on to cornea, where there is a small opacity at its center. Cornea is insensitive. The hairs of eyebrow and eyelashes are largely missing. There is an abundant growth of hair upon the scalp which is free from all manifestations of the disease. The ulnar nerve is palpable as a whip cord at the left elbow. Both hands are the seat of secondary atrophy of hyper- and hypothenar eminences. The interossei are atrophied with the result that the "Main en griffe" is developed. The lepra bacillus was recovered from the nasal secretion.

Case 2. **Argyrosis of conjunctiva and cornea.** Male, 65 years old, Russian; eighteen years ago Dr. Weeks operated for trichiasis, restoring the lid margins in both eyes. At the present time he presents in both eyes a very marked pigmentation of the ocular conjunctiva which is almost black. The cornea likewise in both eyes is stained, the color being a dark brown. About ten injections of 1% "K. I." were made into the conjunctiva without any result being obtained.

Case 3. **Cholesterin crystals in hypermature cataract.** Female; 62 years old; American; complains of poor vision in O. S. for the past few years, with oblique illumination; many glistening points are seen in the opaque lens. This is probably a degenerative process.

Dr. MARTIN COHEN presented an **apparatus for securing a red free light for fundus examination** by means of a Wrattner film filter. (This will appear later.)

Dr. J. G. DWYER then read the paper of the evening on **a further report on the treatment of focal infections of the eye from the intestinal standpoint.** (This paper appeared in the previous issue.) The method employed consisted of intestinal irrigations with various solutions, especially anhydrous sodium carbonate, with the idea of removing, so far as possible, ab-

normal flora, restoring the normal reaction of the intestinal contents, and at the same time making implantations of the colon bacillus. Dr. Dwyer reported many cases illustrating the beneficial effects on numerous chronic eye conditions.

Mr. J. J. CONNELLAN discussed the paper from the standpoint of the laboratory man. (His discussion appeared in the preceding issue.)

Dr. J. A. MCCREERY said he had used the treatment in a great variety of medical and surgical conditions and had had no complete failures and many marked successes. He was very enthusiastic but his experience did not include eye conditions.

Dr. LEO KESSELL also spoke from the standpoint of the internist. His experience had been very favorable but he thought at present the method was in more danger from its friends than its opponents. It was being used indiscriminately on all sorts of ill selected cases and might easily be discredited.

Dr. WM. E. DEEKS had had no experience with the method but thought many of the results could be brought about equally well by regulation of diet. He alluded to the recent experiments showing the marked control on the intestinal flora exercised by appropriate dietaries and emphasized the importance of cutting out the sugars and starches. The first had been added to the list of human foods within comparatively recent years and was everywhere being used in excess. It was responsible for much of the excessive acidity.

Dr. G. H. BELL said that this was a subject in which he was very much interested, and was sorry that he did not have the facilities for carrying on this work at the hospital. He agreed with Dr. Deeks that we must consider the cane sugars and carbohydrates as great factors in producing acid stools and in destroying the colon bacillus in the intestines. We must remember that the carbohydrates are aldehyde and ketone derivatives of complex alcohols. Dr. Bell then reported a case of toxic amblyopia in a woman, aged twenty-seven, who had been a great consumer of candy and two or three sodas a day. Her vision when first seen was $\frac{20}{200}$. Her fields showed a central scotoma extending from the blind spot to the fixation point. Dr. Bell had a chemical analysis of blood made, which showed a high blood sugar (0.18 per cent.). Her Wassermann

was negative. Her urine showed high specific gravity, 1027, and a positive reaction for sugar, and high indican reaction.

The average glucose content of normal blood is 0.10 per cent. The increase in her case, Dr. Bell thought, was brought about by the excessive ingestion of candy and sweets, for the reason that after the ingestion of large amounts of cane sugar or glucose, causing the assimilation limit to be exceeded, an alimentary glycosuria would arise.

The patient was taken off of all sweets and carbohydrates and given the Bulgarian bacillus internally. At the end of three months' treatment, her vision was normal. This was a case of autotoxæmic amblyopia due to the anomalies of metabolism.

Dr. Bell held that every case of retrobulbar neuritis should have a chemical analysis of blood made. Estimations of the blood sugar are undoubtedly of great value in treating these cases of toxic amblyopia.

Dr. J. G. DWYER in conclusion said that, excluding syphilis and tuberculosis, most of the low grade, non-progressive, fluctuating lesions are due to toxins from the teeth, tonsils, or intestinal tract. Generally both eyes were involved. The treatment has been worked to death. Diet alone has not been sufficient, though every article of food should be cut out that cannot be digested.

MISCELLANEOUS NOTICE.

In the meeting of May 3, 1919, of the Norwegian Society of Science in Christiania the Fridtjof Nansen Prize—Kr. 2000—was awarded to Hj. Schiötz and S. Holth for prominent work on glaucoma.

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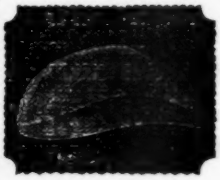

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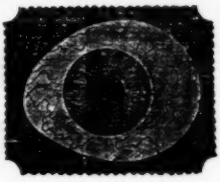

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